No. QB45.G96 1822

THE TRVSTEES OF THE PVBLIC LIBRARY
LVX
OMNIVM CIVIVM
MDCCCLII
MDCCCLXXVIII
OF THE CITY OF BOSTON
1852 · 1878

Boston Public Libra

in this book

2B45.G78 1822
39999 06569 5130

DEFINITIONS

AND

ELEMENTARY OBSERVATIONS

IN

ASTRONOMY;

ALSO,

PROBLEMS ON THE GLOBES.

To which a collection of Geometrical Definitions
is prefixed.

BY SAMUEL R. GUMMERE.

7029.40

PHILADELPHIA:
PUBLISHED BY KIMBER AND SHARPLESS,
No. 93 Market Street.
I. Ashmead & Co. Printers.
1822.

The work is particularly designed as a basis or text book for a course of explanations or lectures on the subject; yet it is believed that when no such explanations are given, the pupil may derive considerable advantage from committing the definitions to memory, and reading the observations attentively.

The description of the artificial globes with the method of performing problems upon them, seemed to be a natural appendage to the preceding part of the work.

Some of the geometrical definitions are absolutely necessary as a preparation for the succeeding observations; and a knowledge of the whole of them will frequently be useful in the ordinary occurrences in life.

GEOMETRICAL

DEFINITIONS.

1. **Geometry** is that science in which the properties of magnitudes are considered.

2. A *point* is that which has position but not magnitude.

3. A *line* is length without breadth.

4. A *straight*, or *right line*, is the shortest line that can be drawn between any two points.

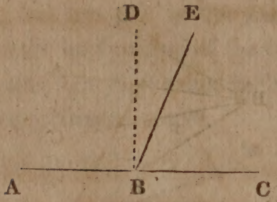
5. A *superficies*, or *surface*, has length and breadth but not thickness.

6. A *plane superficies** is that in which, if any two points are taken, the straight line that joins them lies wholly in that superficies.

---

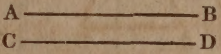
* The plane superficies is frequently called a *plane.*

a right angle. Thus EBC is an acute angle.



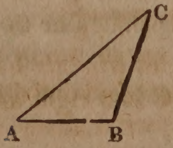
13. An *obtuse angle* is one that is greater than a right angle. Thus ABE, in the preceding figure, is an obtuse angle.

14. *Parallel straight lines* are such as are in the same plane, and which, if they be produced ever so far both ways, will not meet. Thus AB and CD are parallel straight lines.

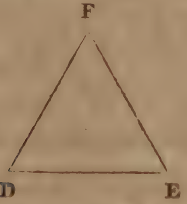


15. A *rectilineal figure* is a space bounded by three or more straight lines.

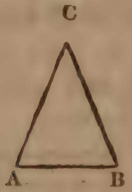
16. A *plane triangle* is a figure bounded by three straight lines. Thus ABC is a plane triangle.



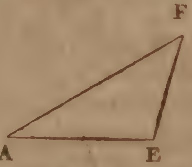
17. An *equilateral triangle* has all its sides equal to each other. Thus DEF is an equilateral triangle.



18. An *isosceles triangle* has but two of its sides equal to each other. Thus ABC is an isosceles triangle.

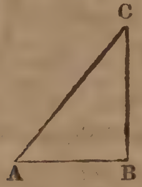


19. A *scalene triangle* has all its sides unequal. Thus AFE is a scalene triangle.

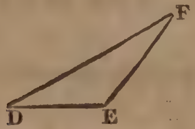


20. A *right angled triangle* has one right angle. Thus ABC is a right angled trian-

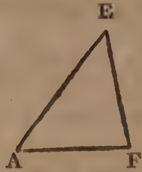
gle. The side AC, opposite the right angle is called the *hypothenuse;* AB the *base;* and BC the *perpendicular.*



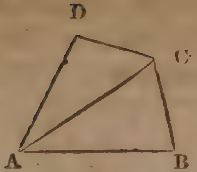
21. An *obtuse angled triangle* has one obtuse angle. Thus DEF is an obtuse angled triangle.



22. An *acute angled triangle* has three acute angles. Thus AEF is an acute angled triangle.

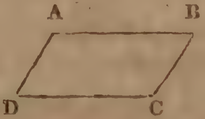


23. Any plane figure bounded by four straight lines is called a *quadrilateral.* Thus ABCD is a quadrilateral figure.

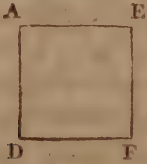


24. The right line which joins the opposite angles of a quadrilateral figure, is called a *diagonal.* Thus AC, in the preceding figure, is a diagonal.

25. Any quadrilateral whose opposite sides are parallel to each other, is called a *parallelogram.* Thus ABCD is a parallelogram.

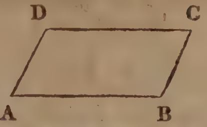


26. A *square* is a parallelogram whose sides are all equal, and whose angles are all right angles. Thus AEFD is a square.

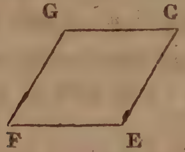


27. A *rhomboides* is a parallelogram whose opposite sides are equal, and whose angles

are not right angles. Thus ABCD is a rhomboides.



28. A *rhombus* is a parallelogram whose sides are all equal, and whose angles are not right angles. Thus FECG is a rhombus.



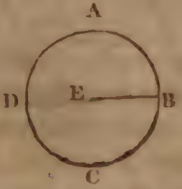
29. All quadrilateral figures that are not parallelograms are called *trapeziums.*

30. All plane figures bounded by more than four straight lines are called *polygons;* those bounded by five straight lines are called *pentagons;* those by six, *hexagons;* those by seven, *heptagons;* and so on.

31. A *regular polygon* is one whose sides, as well as angles, are all equal.

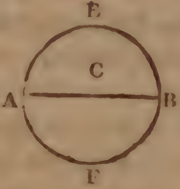
32. A *circle* is a plane figure bounded by one curve line, called the *circumference* or *periphery,* every part of which is equally distant from a certain point within the fi-

gure, called the centre. Thus the figure AB CD is a circle; the curve line ABCD is the circumference or periphery; and E is the centre.



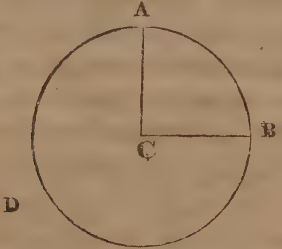
33. The *radius* of a circle is a straight line drawn from the centre to the circumference.—Thus EB is the radius of the circle ABCD.

34. The *diameter* of a circle is a straight line drawn through the centre, and terminated both ways by the circumference.—Thus ACB is a diameter of the circle AE BF.—The diameter divides the circle into two equal parts called *semicircles*.



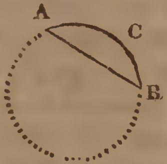
34. The circumference is frequently called a circle, as well as the figure it encloses.

35. A *quadrant* is the fourth part of a circle or of its circumference.—Thus ACB or AB is a quadrant.



36. An *arc* of a circle is any part of the circumference.—Thus AB and ADB, in the preceding figure, are arcs of the circle ABD.

37. The *chord* of an arc is the straight line that joins the extremities of that arc. —Thus AB is the chord of the arc ACB.

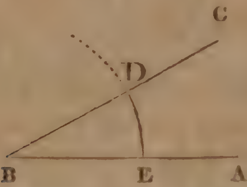


38. A *segment* of a circle is the figure contained by an arc and its chord.—Thus

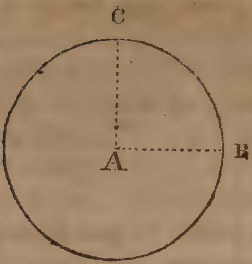
ACBA, in the preceding figure, is a segment of a circle.

39. The circumference of every circle is supposed to be divided into 360 equal parts called *degrees*; each degree into 60 equal parts called *minutes*; and each minute into 60 equal parts called *seconds*.

40. The *measure* of an angle is the arc of a circle included between the lines that form the angle, the angular point being the centre of the circle.—Thus the angle ABC is measured by the arc DE, and contains the same number of degrees that the arc does.

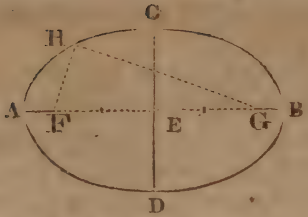


41. The *measure* of a right angle is a quadrant, and is therefore 90 degrees.—Thus the measure of the right angle CAB is the quadrant CB which is one fourth of the circumference, or 90 degrees.



42. The degrees, minutes, and seconds in an arc or angle are commonly written thus, 50° 25′ 36″; which signifies that the given arc or angle contains 50 degrees, 25 minutes and 36 seconds.

43. If two pins be set firmly in the points F and G, and a thread double the length of the line FB or AG have its ends fastened together and be put round the pins; then if a pencil be placed within the thread so as to stretch it tight, as represented by the dotted lines, FG, GH, and HF, and be moved round, it will describe the curve line AHCBD, which is called an *ellipsis*.



44. The points F and G are called the *foci* of the ellipsis.

45. The straight line AB is called the *transverse diameter*; and CD the *conjugate diameter* of the ellipsis.

46. The point E where the transverse and conjugate diameters intersect each other is called the *centre* of the ellipsis.

47. The line EF or EG, is called the *eccentricity* of the ellipsis.

48. A straight line is *perpendicular*, or at *right angles* to a plane, when it makes right angles with every straight line which meets it in that plane.

49. The *inclination of a straight line to a plane* is the acute angle contained by that line and another straight line drawn in the plane from the point where the first line meets the plane, to the point in which a perpendicu-

lar, drawn from the first line to the plane, meets the plane.

50. The *inclination of two planes to each other,* is the acute angle contained by two straight lines drawn from any point in the line of their common section, at right angles to that line, one line in one plane, and the other in the other plane.

51. Planes are said to be *parallel to each other,* which do not meet, though produced ever so far.

52. A *sphere* is a solid body formed by the revolution of a semicircle about its chord which remains fixed.

53. Any straight line that passes through the centre of a sphere, and is terminated both ways by the spherical surface, is called a *diameter* of that sphere.

54. Any circle on the surface of the sphere, whose plane passes through the centre of the sphere, is called a *Great Circle.*

55. Circles on the surface of the sphere whose planes do not pass through the centre, are called *Small Circles.*

56. The *Axis* of a circle is a straight line passing through the centre of the

sphere, perpendicular to the plane of the circle.

57. The two points where the axis of the circle intersects the surface of the sphere, are called the *Poles* of the circle.

ELEMENTARY DEFINITIONS, &c.

IN

ASTRONOMY.

Astronomy is the science which treats of the motions, magnitudes, and relative distances of the earth and the heavenly bodies.

The earth is a body, nearly spherical in its form, and about 7900 miles in diameter.

The earth revolves from west to east around an imaginary line, passing through its centre, called the *Axis* of the earth.

The two points, where the earth's axis intersects its spherical surface, are called the *Poles of the earth*. That towards the north is called the *North*, or *Arctic pole*—and the other the *South*, or *Antarctic pole*.

If the axis of the earth be extended to the heavens, the two points where it intersects the concave surface will be the *Poles of the heavens.*

If from any place on the earth's surface a line be drawn upwards, in the direction that a plumb line takes when a plummet is freely suspended, the point where it meets the concave surface of the heavens, will be the *Zenith* of that place.

If the line, drawn as in the preceding definition, be extended downwards, the point where it meets the concave surface of the heavens will be the *Nadir* of the place.

A plane that passes through any place on the earth's surface, perpendicular to the line that joins the zenith and nadir, meets the celestial sphere in a circle which is called the *Horizon*, or the *Sensible Horizon*, of that place.

The circle in which a plane, passing through the centre of the earth, parallel to the sensible horizon of any place, meets the celestial sphere, is called the *rational horizon* of that place.

Any circle which passes through the celestial poles is called a *Circle of Declination.*

A circle of declination which passes

through the zenith of any place, is called the *Meridian* of that place.

The meridian cuts the horizon in two opposite points called the *North* and *South* points of the horizon.

A circle drawn through the poles of the earth is called a *Meridian line* or *Terrestrial Meridian.*

A circle in the heavens at equal distances from the celestial poles, is called the *Celestial Equator.*

A circle drawn on the earth's surface at equal distances from the poles is called the *Terrestrial Equator.*

Circles which pass through the zenith and nadir of any place, are called *Vertical Circles.*

The vertical circle which is at right angles to the meridian, is called the *Prime Vertical.*

The prime vertical cuts the horizon in two opposite points called the *East* and *West* points of the horizon.

The *Latitude* of any place is the arc of a terrestrial meridian, intercepted between that place and the terrestrial equator. Latitude is estimated in degrees and minutes, and is either *north* or *south* latitude, according as the place is on the north or south side of the equator.

Circles drawn on the earth's surface parallel to the equator, are called *Parallels of Latitude.*

In every country where either Astronomy or Geography is studied, the meridian passing through some particular place, is called the *First Meridian.*

The *Longitude* of a place is the arc of the equator, intercepted between the first meridian, and a meridian passing through that place. It is estimated in degrees and minutes, and is either *east* or *west* longitude, according as the place is east or west of the first meridian.

The time which elapses between two successive passages of the sun over the meredian of any place is called a *Solar Day.*

The time which elapses between two successive passages of a star over the meridian of any place is called a *Siderial Day.*

The solar day is divided into twenty-four equal parts called *Hours*, each hour into sixty equal parts called *Minutes*; and each minute into sixty equal parts called *Seconds.*

The siderial day consists of 23 hours, 56 minutes, and about 4 seconds of solar time.

Clocks and watches are generally regulated so as to correspond with solar time.

The *Astronomical* day begins when the sun is on the meridian; and the *Civil* or *Common* day begins twelve hours sooner.

If we make repeated observations upon the western part of the horizon, at the close of twilight, we shall find that the sun continually approaches those stars which are situated eastward from him, until at length he will appear to have described a complete circle in the heavens.

The circle which the sun appears to describe among the stars, is called the *Ecliptic.*

The ecliptic cuts the celestial equator in two opposite points called the *Equinoctial Points.*

As the ecliptic cuts the celestial equator in two opposite points, it is evident that one half of the ecliptic is on the north side of the equator, and the other half on the south.

The time when the sun is at the equinoctial point in his passage from the south to the north side of the equator, is called the

Vernal Equinox; and the time when he is at the other equinoctial point in his passage from the north to the south side of the equator, is called the *Autumnal Equinox*.

The terms *Vernal Equinox* and *Autumnal Equinox* are also applied to the equinoctial points themselves.

The ecliptic is divided into twelve equal parts called *Signs*. Each sign, therefore, contains 30 degrees.

The division of the ecliptic commences at the vernal equinox, and the signs are numbered in the direction of the sun's apparent motion in the ecliptic.

The names of the twelve signs, and the characters by which they are usually denoted, are

1. Aries	♈	7. Libra	♎
2. Taurus	♉	8. Scorpio	♏
3. Gemini	♊	9. Sagittarius	♐
4. Cancer	♋	10. Capricornus	♑
5. Leo	♌	11. Aquarius	♒
6. Virgo	♍	12. Pisces	♓

The time which elapses between two successive returns of the sun to the vernal equinox is called a *Tropical Year*.

The tropical year consists of 365 days, 5 hours, 48 minutes, and 52 seconds.

The two points in the ecliptic which are at the distance of 90 degrees from the equinoctial points, are called the *Solstitial Points*.

A circle which passes through the poles of the heavens, and through the equinoctial points, is called the *Equinoctial Colure*. Another, passing through the solstitial point, is called the *Solstitial Colure*.

The time when the sun is at the solstitial point on the north side of the equator is called the *Summer Solstice;* and the time when he is at that on the south side of the equator, is called the *Winter Solstice*.

The angle which the plane of the ecliptic makes with that of the equator is called the *Obliquity of the Ecliptic*. This angle is 23° 28′ nearly; so that the sun, when on the meridian at the time of the summer solstice, is elevated almost 47 degrees more above the horizon, than when on the meridian at the time of the winter solstice.

Two circles whose planes are parallel to that of the equator, and that touch the ecliptic in the solstitial points, are called the *Tropics*. That on the north side of the equator is called the *Tropic of Cancer*, and the other the *Tropic of Capricorn*.

Two circles whose planes are parallel to that of the equator, and that are at the distance of 23° 28′ from the poles, are called the *Polar Circles*. The one near the north pole is called the *Arctic Circle*; and the other the *Antarctic Circle*.

Circles conceived to be drawn on the earth's surface corresponding with the tropics and polar circles, divide it into five parts called *Zones*. That between the tropics is called the *Torrid Zone*; those between the tropics and polar circles are called the *Temperate Zones*; and those within the polar circles are called the *Frigid Zones*.

A great circle that passes through the poles of the ecliptic is called a *Circle of Latitude*.

The *Latitude* of any heavenly body is the arc of a circle of latitude intercepted between that body and the ecliptic.

The *Longitude* of a heavenly body is the arc of the ecliptic intercepted between the vernal equinox and a circle of latitude passing through that body, counting in the direction of the signs.

The *Declination* of a heavenly body is the arc of a circle of declination intercepted between that body and the equator. It is north or south according as the body is north or south of the equator.

The *Right Ascension* of a heavenly body is the arc of the equator, intercepted between the vernal equinox and a circle of declination passing through that body, counting eastward in the direction of the signs of the ecliptic.

OF DAY AND NIGHT AND THE CHANGES OF THE SEASONS.

At all places between the polar circles the sun performs a part of every diurnal revolution above the horizon, and a part below it. The time which the sun remains above the horizon is called *Day;* and that which he remains below the horizon is called *Night.*

At all places on the equator the days and nights are always equal; but at places either north or south of the equator they are constantly varying in length, in consequence of the sun's apparent motion in the ecliptic.

At the vernal and autumnal equinoxes the days and nights are equal at all places on the earth.

From the vernal to the autumnal equinox the days are longer than the nights at all places north of the equator, and the days have the greatest length at the time of the summer solstice; but in the southern hemisphere the nights are longer than the days during this period, and they have the greatest length at the summer solstice.

From the autumnal to the vernal equinox the days are shorter than the nights in the northern hemisphere, and longer than the nights in the southern. The longest night in the northern hemisphere, and the longest day in the southern, occur at the time of the winter solstice.

At places on the north polar circle the sun makes one complete revolution at the summer solstice without descending below the horizon; and at the winter solstice he makes one without ascending above the horizon.

At places on the antarctic circle the sun makes a complete revolution above the horizon at the winter solstice, and one below it at the summer solstice.

Between the polar circles and the poles the length of the day varies from a few minutes, to nearly half a tropical year; and exactly at the poles the sun remains above the horizon during one half the year, and below it during the other half.

In the temperate zones, the tropical year is divided into four seasons: viz. *Spring*, *Summer*, *Autumn* and *Winter*.

Spring commences at the vernal equinox (about the 20th of March) and continues until the summer solstice.

Summer commences at the summer solstice (about the 21st of June) and continues until the autumnal equinox.

Autumn commences at the autumnal equinox (about the 23rd of September) and continues until the winter solstice.

Winter commences at the winter solstice (about the 21st of December) and continues until the vernal equinox.

As the sun's rays are the great source of heat to the earth, it is evident that the change of seasons must depend upon the inclination of the plane of the ecliptic to that of the equator, which causes the sun to remain longer above the horizon at one season than another, and to have a greater altitude when on the meridian.

In the winter the sun remains but a few hours above the horizon, and his rays, in consequence of his small elevation, fall very obliquely on the earth's surface; and consequently, the degree of heat produced is but small.

In summer the sun remains much longer above the horizon, and his elevation being greater, a much greater number of rays fall upon any given surface, than in winter; and consequently the heat is greater.

It must be observed, however, that the greatest heat of summer does not occur until after the summer solstice, when the days are longest, and the sun's elevation greatest; neither does the greatest heat of a single day occur until after the sun has passed the meridian.

OF THE SOLAR SYSTEM.

If we make repeated and accurate observations upon the stars we shall discover that most of them preserve the same relative situation with respect to one another, though they all appear to partake of a general motion from east to west with respect to the earth. We may perceive, however, that a few of them move amongst the others from west to east.

Those stars that preserve the same relative positions with respect to one another are called *Fixed Stars.*

Those stars that have a motion amongst the others from west to east, are called *Wandering Stars,* or *Planets.*

The number of planets now known is ten: viz. *Mercury, Venus, Mars, Vesta, Juno, Ceres, Pallas, Jupiter, Saturn,* and *Uranus.* Of these, five, viz. Mercury, Venus, Mars, Jupiter, and Saturn, were known to the ancients; the other five have been discovered within a few years.

The planets and stars, as was observed above, all *appear* to have a general motion from east to west around the earth as a centre. The sun also appears to partake of the same motion. But these appearances are deceptive. There is no fact more fully established than that this *apparent* motion of the sun and stars, is caused by a real motion of the planets (among which the earth may be numbered) around the sun, from west to east. They move round the sun at various distances, in the order in which they were named above, the *Earth* coming between Venus and Mars.

Several of the planets are attended by smaller bodies which revolve round them as centres, and with them round the sun. These are called *Secondary Planets* or *Satellites.*

The number of satellites is eighteen; of which the Earth has *one* (the Moon,) Jupiter *four*, Saturn *seven*, and Uranus *six*.

Besides the planets and satellites, there are some other bodies that have a motion among the stars, that only appear occasionally in the heavens, and that are accompanied by a faint brush of light called a tail, by which they may be distinguished from the fixed stars and planets. These are known by the name of *Comets.*

The Sun, the Planets with their Satellites, and the Comets, comprise what is called the *Solar System.*

The planets and satellites are all opaque bodies, nearly spherical in form; and they are rendered luminous by reflecting the rays of the sun which fall upon their surfaces.

When viewed with the naked eye the planets appear very little different from the fixed stars, except in magnitude and in brightness; but when viewed with a telescope they present circular, well defined discs.

OF THE SUN.

The sun, which is the great source both of heat and light to all the other bodies in the solar system, and is the common centre about which they all perform their revolutions, is a spherical body of immense size, and, for aught we know is nearly stationary in the heavens. His diameter is about 875,000 miles, and his solid content is equal to about 1,350,000 such bodies as this earth upon which so many millions of living creatures find a supply for all their wants.

When the sun is viewed with a telescope, dark spots may frequently be seen on his surface. The number and magnitude of these spots are extremely variable. Sometimes several weeks, and even months elapse without any of them being visible; and sometimes their number is considerable, and their size so great that they may be seen with the naked eye when the atmosphere is sufficiently hazy to enable us to direct our sight to the sun without injury.

By observations upon the sun's spots it has been ancertained that he performs a revolution upon his axis in a period of about 25 days.

OF THE PLANETS.

The planets, including the earth, all revolve round the sun as their common centre of motion; but they perform their revolutions at very different distances from this centre.

The path which a planet describes in its revolution round the sun, or that described by a satellite in its revolution round a planet, is called the *Orbit* of the planet or satellite.

The orbits of the planets do not all lie in the same plane. That plane in which the earth's orbit lies is called the *Plane of the Ecliptic;* and the orbits of all the other planets cut this plane in small angles.

The two points where the orbit of a planet or satellite cuts the plane of the ecliptic, are called the *Nodes* of that planet or satellite.

The node through which the planet passes from the south to the north side of the ecliptic, is called the *Ascending Node;* and that through which it passes from the north to the south side of the ecliptic, is called the *Descending Node.*

The orbits of all the planets are ellipses whose eccentricity is small; and the sun occupies one of the foci of each of these orbits.

All the planets, except Ceres and Pallas, perform their revolutions round the sun, within a zone of the heavens, extending about eight degrees on each side of the ecliptic. This zone is called the *Zodiac.*

That point in a planet's orbit which is nearest the sun is called the *Perihelion;* and the point which is furthest from the sun is called the *Aphelion.*

When a planet or satellite has such a position in its orbit, that its longitude is the same as that of the sun, it is said to be in *Conjunction*; and when its longitude differs 180 degrees from that of the sun, it is said to be in *Opposition*.

The time which elapses between two successive conjunctions or oppositions of a planet is called a *Synodic Revolution* of that planet.

The time which elapses between two successive returns of a planet to a particular fixed star, is called a *Siderial Revolution* of that planet.

OF THE PLANETS MERCURY AND VENUS.

The planets Mercury and Venus are the first in order receding from the sun; and as their orbits lie within that of the earth, they can never be in opposition. But it is evident, that in making their revolutions, they must sometimes pass between the earth and sun, and sometimes be on the opposite side of the sun from the earth.

When either Mercury or Venus is between the earth and sun, it is said to be in *Inferior Conjunction*; and when either of them is on the opposite side of the sun from the earth, it is said to be in *Superior Conjunction.*

When Mercury or Venus is either in, or very near one of its nodes at the time of inferior conjunction, it appears as a dark spot passing over the sun's disc from east to west. Such a phenomenon is called a *Transit* of Mercury or Venus.

Transits of Mercury are phenomena of not very unfrequent recurrence; but those of Venus are very rare.

The next four transits of Mercury will occur in the years 1832, 1835, 1845, and 1848. They will all be visible in the United States.

The last transits of Venus occurred in 1761 and 1769; and the next two will not take place until the years 1874 and 1882.

By observations made upon transits of Venus on different parts of the earth's surface, astronomers have been enabled to calculate the distances and magnitudes of the other bodies comprised in the solar system, with great accuracy.

Mercury performs a siderial revolution round the sun in 88 days, at the mean distance of 37 millions of miles.

The magnitude of Mercury is but about one sixteenth as great as that of the earth. Its diameter is a little more than 3,000 miles.

Mercury's greatest angular distance from the sun is but about 23 degrees; consequently it is never seen long after the sun sets in the evening, nor long before he rises in the morning. It is but seldom that it can be seen with the naked eye.

Owing to the contiguity of Mercury to the sun, and the difficulty this occasions in making observations upon it, it has not been ascertained whether it revolves on its axis or not.

Venus performs a siderial revolution in about 224½ days, at the mean distance of 67 millions of miles from the sun. Its synodic revolution is performed in 584 days.

The diameter of Venus is 7600 miles (nearly as great as that of the earth) and it performs a revolution on its own axis in about 23 hours, 21 minutes.

The greatest angular distance of Venus from the sun is about 45 degrees.

While Venus is passing from superior to inferior conjunction it is seen, in the evening, near the western part of the horizon, and is called the *Evening Star.* When passing from inferior to superior conjunction, it is seen, in the morning, near the eastern part of the horizon, and is called the *Morning Star.*

When Venus is in superior conjunction the whole of its enlightened disc is turned directly towards the earth, but being then in the same direction as the sun, its light is rendered entirely insensible by the superior splendour of the sun's rays. As the planet advances in its orbit, its angular distance from the sun soon becomes so great that it may be seen just above the horizon during twilight. At this time a small part of its enlightened surface is turned from the earth, and if it be viewed with a good telescope it will present the same appearance as the moon a few days after the full. When the planet arrives at its greatest angular distance east from the sun, only one half of its enlightened disc is turned towards the earth, and it appears in the shape of a semicircle, the convexity of which is turned towards the sun. From this time the enlightened surface gradually diminishes until the planet arrives at inferior conjunction, when, the whole of the enlightened disc being turned directly from the earth, it becomes invisible.

When Venus first appears as morning star, a short time after inferior conjunction, it has the form of the new moon. The enlightened disc gradually increases until the time of superior conjunction, when the whole enlightened surface is turned towards the earth, but is again invisible in consequence of the superior light of the sun.

Those changes in appearance which the planet presents, are called the *Phases of Venus*. It passes through one series of these changes, or through all its phases during one synodic revolution, or 584 days.

Venus is very far inferior in magnitude to some of the other planets; but in consequence of its vicinity both to the sun and the earth, it is, next to the moon, the most conspicuous of all the bodies that appear in the heavens, while the sun is below our horizon. It is the most brilliant a short time before, and after inferior conjunction, when only about one fourth of its enlightened surface is visible. At this time, it may be seen during the day, without the aid of a telescope.

Mercury also undergoes changes in appearance, similar to those of Venus; but in consequence of its contiguity to the sun they cannot be so satisfactorily examined.

OF THE EARTH AND MOON.

To a superficial observer the earth appears to be the common centre about which all the heavenly bodies perform their daily revolutions; and he would judge it to be much larger than all other bodies combined together. But by astronomical investigation it has been ascertained that the earth, instead of remaining at rest as the common centre of motion for the heavenly bodies, is constantly moving through space with the astonishing velocity of more than 68 thousand miles per hour; and that when its magnitude is compared with that of the sun, or of the planet Jupiter, it sinks into absolute insignificance.

The earth has the form of an oblate spheroid, the diameter at the equator being 25 miles greater than that through the poles; and it performs its annual revolution round the sun, in an elliptical orbit, at the mean distance of 94 millions of miles.

The *Tropical Revolution* of the earth, that is its revolution from the vernal equinox, to the same point again, is performed in 365 days, 5 hours, 48 minutes, and 52 seconds, which is exactly the time required for the *apparent* tropical revolution of the sun.

The eccentricity of the earth's orbit, or the distance from the centre to the focus occupied by the sun, is about 1,680,000 miles; hence it is evident that when the earth is in the perihelion of its orbit, it must be almost three millions four hundred thousand miles nearer the sun, than when in the aphelion. Now, as the sun, is the great source of heat to the earth, it would, at first thought, be very natural to suppose that we should have our warmest weather when the earth is in perihelion, and our coldest when it is in aphelion. But at places in north latitudes the fact is directly the reverse; for the earth is nearest the sun, or in perihelion, about the first of January, just at the commencement of our coldest weather, and is furthest from the sun, or in aphelion, about the first of July, the time of our warmest weather.

If there were no counterbalancing cause, this difference of more than three millions of miles in the distance of the earth from the sun, would undoubtedly produce a perceptible difference in the warmth of our weather. But the difference of temperature, that this inequality of distance would produce at any given place, is small compared with that produced by the different lengths of the days, and the different altitudes of the sun.

The axis of the earth is not perpendicular to the plane of its orbit, but is inclined to it in an angle of about 66 degrees 32 minutes; and in every part of the orbit the axis has the same inclination, or, in other words it always continues parallel to itself.

If the earth's axis were perpendicular to the plane of its orbit, the apparent annual motion of the sun would be in the equator; and, admitting the motion of the earth in its orbit to be uniform, the time between two successive passages of the sun over the meridian of any place, would always be the same. But the apparent annual motion of the sun is not in the equator, and the motion of the earth in its orbit is not uniform, being more rapid when near the perihelion, than when near the aphelion. These two causes combined produce a considerable inequality in the times between two successive passages of the sun over the meridian. at different seasons of the year.

The time that is actually denoted by the successive passages of the sun over the meridian, his apparent motion being irregular in the ecliptic, is called *Apparent Time.*

The time that would be denoted by the successive passages of the sun over the meridian supposing his apparent annual motion to be uniform in the equator, is called *Mean Time.*

A clock, when well regulated and properly adjusted, denotes *mean time;* and a good sun-dial denotes *apparent time.*

The difference between mean, and apparent time, is called the *Equation of Time.*

The equation of time varies from nought to more than sixteen minutes. It is greatest about the first of November, when a well regulated clock should be about sixteen minutes slower than a correct sun-dial.

OF THE EARTH'S ATMOSPHERE.

The earth is surrounded by an invisible, elastic fluid which accompanies it in its annual motion round the sun, and turns with it in its diurnal motion upon its own axis. This fluid is called the *Earth's Atmosphere*, and it performs a number of very important offices in the regular operations of nature, at and near the surface of the earth. It is the principal agent in elevating water, in the state of vapour, from the surface of the ocean, wafting it in clouds over the land, and discharging it in the form of rain, hail, or snow. It is essential also in the operations of respiration and combustion. In fact, without such a fluid around it, the earth would be nothing more than a vast, dreary waste, upon which no living thing, either animal or vegetable could exist.

The atmosphere gradually decreases in density as we ascend from the earth's surface, so that a person who rises to the height of three or four miles, always experiences a difficulty of breathing. It is not known to what height it extends, but at the height of thirty-five miles it is so rare as not to produce any sensible effect upon the rays of light which pass through it.

REFRACTION.

If a ray of light continues to move in a medium whose density is every where the same its direction is straight; but if it enter obliquely into another medium whose density is greater, its direction will be changed immediately, and it will then pass on again in a straight line, more nearly perpendicular to the surface of the medium it has entered. If it pass from a denser to a rarer medium, its direction will be further from a perpendicular to the surface.

If the ray move through a medium whose density gradually increases or diminishes as it passes along, it will describe a *curve* line. Thus, if a ray of light enter obliquely into the earth's atmosphere, in its passage from one of the heavenly bodies, it will describe a *curve* line, concave towards the earth, and the more obliquely it enters the more its direction will be changed. This change which the rays of light suffer in their direction when passing from one medium to another, or when passing through a medium whose density varies, is called *Refraction.*

It appears then, from what was stated above, that the refraction occasioned by the atmosphere must cause the heavenly bodies to appear more elevated than they really are, and that the difference between the real and apparent elevation must be greatest when the body is near the horizon, as the rays then enter the atmosphere more obliquely than when the body is considerably elevated. In consequence of this refraction the sun or any of the other heavenly bodies may be seen a short time before it reaches the horizon in the east, and after it descends below it in the west.

After the sun has actually descended below the horizon, and has disappeared, its rays, for a considerable time, reach the more elevated parts of the atmosphere and are refracted, and reflected in such a manner as to occasion considerable light, which gradually diminishes as the sun descends, and thus prevents an immediate transition from the light of day to the darkness of night. The same effect, though in a contrary order, takes place before the sun comes to the horizon in the morning. The light thus produced, is called the *Crepusculum,* or *Twilight.*

It is generally reckoned that the twilight continues until the sun descends 18 degrees below the horizon in the evening, and commences again when it has approached within 18 degrees of it in the morning.

If observations be made at any place, it will be observed that the apparent, diurnal path of the sun cuts the horizon more obliquely at one season of the year than another; and it must follow as a consequence that when it cuts it most obliquely the twilight will be longest, as it must then require more time for the sun to descend 18 degrees below the horizon. In northern latitudes the twilight is longest when the sun has its greatest meridian altitude, which is about the 21st of June, and it is shortest when the sun's declination is a few degrees south. The time of shortest twilight varies a little with the latitude of the place. In 40 degrees north latitude, it is about the 8th of October and the 6th of March; but in 60 degrees north latitude, it is about the 14th of October and the 28th of February.

The duration of twilight is much greater in high latitudes than near the equator. In 66½ degrees north, the sun will not descend so much as 18 degrees below the horizon for a number of successive days immediately before the summer solstice nor for a similar number after it. Hence, during this time the whole of their night is similar to our evening or morning twilight.

OF THE MOON.

The moon, which, next to the sun, is the most conspicuous of the heavenly bodies, is a satellite of the earth, and revolves round it from west to east at the mean distance of 240,000 miles.

The diameter of the moon is about 2160 miles, and its solid content is about one forty-ninth part of that of the earth.

The orbit of the moon is an ellipsis, of which the eccentricity is rather more than 13,000 miles. It cuts the plane of the ecliptic in an angle of about 5 degrees. The two points, where the orbit intersects the plane of the ecliptic, are called the *Moon's Nodes*.

The point in the moon's orbit nearest the earth is called the *Perigee;* and that which is farthest from the earth is called the *Apogee.* The apogee and perigee are sometimes called the *Apsides* of the moon's orbit; and the line which joins them is called the *Line of the Apsides.*

As the earth occupies one focus of the moon's orbit, the moon is about 26,000 miles nearer to us when in perigee, than when in apogee.

The moon's nodes are not stationary, but have a motion in a direction contrary to that of the moon in its orbit. This motion is subject to several irregularities and diminishes slowly from century to century. At present the mean length of a revolution of the nodes is 18 years 224 days.

The apsides of the moon's orbit have a motion from west to east, by which they perform a revolution in about 8 years 309 days.

If on any evening we notice the situation of the moon with respect to some particular fixed star, we shall find by observation on the succeeding evening that it has advanced considerably to the eastward; and in about 27 days 8 hours, it will have made a com plete revolution in the heavens. This is called the *Siderial Revolution* of the moon.

The moon revolves on its own axis in the same time that it requires to perform a revolution round the earth, and consequently presents at all times nearly the same surface to our view.

The time that elapses between two successive passages of the moon over the meridian of any place is called a *Lunar Day*. It consists of 24 hours, 50 minutes, 48 seconds.

The moon is an opaque body which only affords light to the earth by reflecting a part of that which it receives from the sun. Hence, at the time of conjunction, as the enlightened hemisphere of the moon is turned directly from the earth, it entirely disappears. It is then said to be *New Moon*.

In the course of one to two days after new moon, it again becomes visible, in the evening near the western part of the horizon. The luminous part has the shape of a circular segment, the exterior boundary of which is a semicircle, and the interior a semi-ellipsis. At this time the whole disc of the moon may be distinctly seen, though the circular segment (called a *Crescent*) is much more luminous than the rest. The less luminous segment is rendered visible by light which is reflected from the earth to the moon, and from that back to the earth.

From the first appearance of the moon after new moon, the luminous segment gradually increases in breadth as the moon advances eastward in its orbit, till in a little more than 7 days from the time of new moon, its longitude differs 90 degrees from that of the sun. This is called the *First Quarter.* The luminous segment then has the form of a semicircle; and the moon is said to be *Dichotomized.*

After first quarter, as the moon passes on in its orbit, the side of the segment opposite the sun becomes convex, and it gradually increases in breadth until the moon is in opposition. At this time, the whole of the enlightened hemisphere is turned towards the earth, and the moon has the shape of an entire circle. It is then said to be *Full Moon.* This occurs about 15 days after new moon.

After full moon the western side of the luminous surface becomes elliptical, and the breadth gradually decreases until, in about 22 days from new moon, the longitude of the moon differs 270 degrees from that of the sun, when the luminous segment again has the form of a semicircle. It is then said to be *Last Quarter.*

After the last quarter, the western side of the visible segment becomes concave, and the breadth of it continues to decrease, until the moon disappears a day or two before conjunction, or new moon.

The interval from new moon to new moon again, or from full moon to full moon, is called a *Lunation* or *Lunar Month.* It is the same as the synodic revolution of the moon, and its mean length is 29 days, 12 hours, 44 minutes, 3 seconds.

If, at the time of new moon, the moon is at or near one of its nodes, as it is an opaque body, and is then directly between the earth and sun, it is evident that it must prevent a part, at least, of the sun's light from falling on some part of the earth's surface. This phenomenon frequently occurs, and is called an *Eclipse of the Sun.*

If, at the time of full moon, the moon is at or near one of its nodes, it is directly on the opposite side of the earth from the sun, and consequently it must be in the earth's shadow, and be either wholly, or in part, deprived of the direct light of the sun. This phenomenon is called an *Eclipse of the Moon.*

When the moon passes between the earth and any particular star or planet, it occasions what is called an *Occultation* of that star or planet.

ECLIPSES OF THE SUN.

As the orbit of the moon is an ellipsis, of which the earth occupies one of the foci, it is evident that its distance from the earth must be constantly varying, and that its apparent diameter must increase or diminish, according as it approaches to the earth, or recedes from it. The diameter will be greatest, when the moon is in perigee, and least, when it is in apogee.

Similar observations may be applied to the sun. Its apparent diameter will be greatest when the earth is in perihelion, and least, when it is aphelion.

Although the *real* diameter of the sun is more than four hundred times as great as that of the moon, yet as the sun is 94,000,000 of miles from the earth, and the moon only 240,000 miles from it, their *apparent* diameters are nearly the same. In consequence of the variations in their distances, their apparent diameters may alternately surpass each other.

If the moon is at or very near one of its nodes at the time of conjunction, or new moon, the straight line joining the centres of the sun and moon may meet the eye of an observer situated on the earth's surface; and if the apparent diameter of the moon be then greater than that of the sun, the sun will be entirely obscured, at the place where the observer is situated, or will suffer a *Total Eclipse.*

But if, at this time, the apparent diameter of the sun be greater than that of the moon, a part of the sun will be visible in the form of a ring around the dark body of the moon. Such a phenomenon is called an *Annular Eclipse of the Sun.* The next annular eclipse, at Philadelphia and parts adjacent, will occur September 18th, 1838.

If, at the time of conjunction, the situation of the moon, with respect to the node, is suc that the line joining the centre of the sun an the eye of an observer on the earth's surface passes either north or south of the centre o the moon, the moon may then obscure onl the north or south part of the sun's disc, an occasion a *Partial Eclipse.*

The difference in the respective distances of the sun and moon from the earth, and i the proximity of the moon to the node, may produce a great variety of solar eclipses, i which greater or less portions of the sun's disc will be obscured.

As the apparent diameter of the moon is never much greater than that of the sun, the conical shadow which the moon casts towards the earth at the time of an eclipse, must always approach nearly to a point by the time it falls upon the earth; and when the apparent diameter of the moon is less than that of the sun, the shadow must come to a point before it reaches the surface of the earth. Hence it may readily be inferred, that while the sun is totally or partially eclipsed to the inhabitants of one part of the earth, to those of other parts he may appear in his usual splendour; in the same manner as the shadow of a cloud that is wafted by the wind, passes over the hills and valleys, obscuring the sun to those that are in its course, while others at a little distance are scorched by his rays.

As the sun may be eclipsed at one place, while at others he is shining with full splendour; so the same eclipse may appear of various magnitudes as viewed at different places. When an eclipse of the sun is total to the inhabitants of one part of the earth, to those a few hundred miles north or south of these, it may only be a partial eclipse on the north or south of part of the sun's disc.

ECLIPSES OF THE MOON.

The earth projects behind it, relative to the sun, a conical shadow, which ends in a point, at the mean distance of 858,000 miles from the earth's centre; and as the moon revolves round the earth at the mean distance of 240,000 miles from it, a simple calculation will show that the diameter of a circular section of the shadow, at this distance, must be about 5,700 miles. If then, the moon, at the time of opposition, be within 1700 miles north or south of the node, it must be wholly immersed in the earth's shadow, and be entirely deprived of the direct light of the sun Such a phenomenon is called a *Total Eclips of the Moon.*

But if the moon be more than about 1,700 miles north or south of the node at the time of opposition, it must either pass entirely clear of the earth's shadow, or be only in part immersed in it. When but a part of the moon passes through the shadow, the phenomenon is called a *Partial Eclipse of the Moon.*

The preceding observations suppose the moon to be at its mean distance, or 240,000 miles from the earth. But when in perigee, its distance from the earth is but about 227,000 miles; and when in apogee it is about 253,000 miles. Consequently the diameter of a circular section of the earth's shadow, at the former distance, is more than 5,700 miles, and at the latter distance, less.

If then the moon be in apogee at the time of opposition, it must be nearer the node, in order that an eclipse may occur, than would be necessary at its mean distance from the earth.

But if the moon be in perigee at the time f opposition, its distance from the node, in rder for it to suffer an eclipse, may be reater than when at its mean distance from he earth.

Eclipses of the moon differ from those of he sun with respect to the appearances they resent at different places on the earth's surace. An eclipse of the sun is of greater or ess magnitude according to the place at hich it is viewed; but an eclipse of the oon has the same magnitude at all places here it is viewed, however widely they may e separated.

The cause of this difference between clipses of the sun, and those of the moon, ay be briefly stated as follows. The sun ecomes eclipsed in consequence of some of hose rays which he is continually emitting, eing intercepted by the moon, in their assage to a part of that hemisphere which turned toward the sun. But the moon eclipsed in consequence of being actually eprived, either wholly or in part, of that ght which it, at other times, receives from he sun and reflects to the earth.

Although the moon, when totally eclipsed, entirely deprived of the *direct* light of the sun, it does not become wholly invisible. The rays of the sun which pass through the earth's atmosphere, are converged by it and caused to meet at a distance from the earth less than that of the moon. These rays afford sufficient light to the moon to render it visible, and cause it to appear of a dull reddish colour, even in the middle of a total eclipse.

GENERAL OBSERVATIONS ON ECLIPSES.

Eclipses both of the sun and moon, may be foretold with great certainty, by means of astronomical calculations, many years before they occur. Not only the day, but the hour, and even the minute, when any particular eclipse will commence, may be calculated half a century or more before it takes place; and the time when the eclipse will be greatest, and when it will end, may be ascertained with equal accuracy. And as these calculations depend upon an accurate knowledge of the situations of the sun and moon at the identical point of time that the eclipse commences or ends, as well as of the distances of those bodies from the earth, and of their relative magnitudes; the young student may hence infer, that when the magnitudes, distances, &c. of the heavenly bodies are given in thousands, or millions of miles, these numbers are not given at random, but are the results of accurate calculations. We may with safety assert that the distance between the sun and earth is more accurately known, than the distance between the cities of Philadelphia and New-York.*

An eclipse of the sun can only occur at the time of new moon, and an eclipse of the moon, at the time of full moon.

Eclipses do not occur at every new and full moon, because the moon is not always sufficiently near the node, at these times.

The greatest number of eclipses that can occur in any one year is *seven;* and the least number is *two.*

The average number of eclipses in a year is *four.*

When seven eclipses occur in one year, *five* of them must be of the *sun,* and *two* of the *moon.*

---

* We do not mean, that we know the distance between the sun and earth within 5 or 6 miles, as we probably do the distance between Philadelphia and New-York; but that we know it more accurately in proportion to the whole distance.

When only two occur in one year they must both be of the sun. In every year there are at least two eclipses of the sun.

There are more eclipses of the moon visible at any particular place, than of the sun, because an eclipse of the sun is confined to a comparatively small portion of the earth, whereas an eclipse of the moon is always visible, cloudy weather excepted, to the inhabitants of more than one half the earth.

The greatest duration of an eclipse of the sun at any one place is about 3 hours 44 minutes. The greatest duration of an annular eclipse of the sun is 12 minutes; and the greatest duration of a total eclipse of the sun is 8 minutes.

The greatest duration of an eclipse of the moon, at any particular place, is nearly 4 hours, and the greatest duration of a total eclipse of the moon, is about 1 hour 45 minutes.

The diameter of the disc of the sun or moon is supposed to be divided into twelve equal parts called *Digits;* and the magnitude of an eclipse is expressed by giving the number of these digits that are obscured. Thus an eclipse of 8½ digits, is one in which

8½ twelfths of the sun or moon's diameter is obscured.

OF THE PLANET MARS.

The orbits of Mercury and Venus being included within the orbit of the earth, they are called *Inferior Planets;* but as the orbits of all the others lie beyond that of the earth, they are called *Superior Planets.*

The superior planets may be in opposition as well as conjunction, but they cannot exhibit the different phases which the inferior planets present to us. When viewed with telescopes, they at all times present discs that vary but little from complete circles.

Mars performs a siderial revolution round the sun in about 687 days, at the mean distance of 143 millions of miles.

As the mean distance of the earth from the sun is 94 millions of miles, it is evident that Mars must be about five times as far from the earth when in conjunction, as when in opposition. This difference in distance produces a corresponding difference in the apparent diameter of this planet. When it is seen early in the evening near the eastern part of the horizon, it is abundantly more conspicuous, than when seen at the same time in the evening near the western part of the horizon.

The diameter of Mars is about 4000 miles, and consequently its solid content is nearly one seventh as great as that of the earth. It revolves on its own axis from west to east in 24 hours 39 minutes.

Mars may be distinguished from all the other planets, by its dusky red light.

JUPITER AND ITS SATELLITES.

Jupiter is the largest, and also the most brilliant of the planets, Venus excepted. It performs a siderial revolution round the sun, in 4333 days, or nearly 12 years; and its mean distance from the sun is about 490 millions of miles.

The diameter of Jupiter is 89,000 miles, which is more than eleven times the diameter of the earth. Its solid content is therefore nearly fourteen hundred times as great as that of the earth.

Jupiter revolves from west to east, on an axis nearly perpendicular to the plane of the ecliptic, in 9 hours 56 minutes.

When Jupiter is examined with a good

telescope, its disc is observed to be crossed, on both sides of the centre, by several obscure spaces or stripes, which are nearly parallel to each other, and to the plane of the ecliptic. These are called the *Belts* of Jupiter.

When Jupiter is viewed with a telescope, even of moderate powers, it is seen to be accompanied by four small stars, which appear to be nearly in a straight line, parallel to the plane of the ecliptic. These stars, which always accompany Jupiter, and revolve round it, as the moon revolves round the earth, are called the *Satellites* of Jupiter.

The Satellites of Jupiter are continually changing their situations with respect to one another, and to the planet itself. They are sometimes all to be seen on one side of the planet, and sometimes all on the other; but more commonly, a part of them are on one side and a part on the other.

The greatest distance to which they recede from the planet, is different for the different satellites; and they are distinguished from each other according to their distances. That which recedes to the least distance, is called the *First* satellite; that which recedes to the next greater distance, is called the *Second* satellite; and so on to the *Fourth.*

As the satellites of Jupiter revolve round him in orbits nearly parallel to the ecliptic, they sometimes pass directly between the earth and the planet, and are not easily distinguished from the planet itself; and sometimes they pass directly on the opposite side of Jupiter from the earth, and of course become entirely invisible.

Jupiter being an opaque and nearly spherical body, must project a conical shadow in a direction opposite to the sun. When either of the satellites enters this shadow, it loses its light, and becomes invisible. This phenomenon is called on *Eclipse* of the satellite.

Observations upon the eclipses of Jupiter's satellites, have led to the discovery of the *Velocity of Light.* From these observations it is ascertained that light traverses a space equal to the whole diameter of the earth's orbit in 16 minutes 26 seconds; and consequently that it is 8 minutes 13 seconds in passing from the sun to the earth.

It has therefore the amazing velocity of 190,000 miles per second.

The eclipses of Jupiter's satellites also furnish a simple means of ascertaining the longitudes of different places on the earth's surface.

SATURN, HIS SATELLITES, AND RING.

The planet Saturn, which is next in order to Jupiter, performs a siderial revolution round the sun in 10,758 days, or nearly twenty-nine and a half years, at the mean distance of 900 millions of miles.

The diameter of Saturn is about 79,000 miles, and it revolves on its axis, which makes an angle of 60 degrees with the plane of the ecliptic, in 10 hours 16 minutes.

Saturn, when viewed with a telescope, is readily distinguished from all the other planets, by a broad, luminous, circular ring, which surrounds the body of the planet, but is entirely detached from it. This ring, which is of inconsiderable thickness, is opaque, and is rendered visible, like the planet itself, by reflecting the light of the sun.

The plane of the ring is inclined to the plane of the ecliptic in an angle of 31 degrees 24 minutes; and consequently the face of the ring can never be turned directly towards the earth. It is generally seen under the form of an eccentric ellipsis, the conjugate diameter of which, when in its most favourable situation, is about one half as great as the transverse.

Saturn's ring cannot always be seen, even with the aid of the best telescopes. It may become invisible from three distinct causes; first, from the enlightened side being turned directly from the earth; secondly, from the edge of the ring being turned towards the earth; and lastly, from the edge of the ring being turned directly towards the sun.

When Saturn is viewed with a telescope of moderate magnifying powers, the ring appears to be entire; but when viewed with those of the highest magnifying powers, it is discovered to be composed of two concentric rings, which are entirely separate from each other. The distance from the centre of the planet to the inside of the interior ring is 73,000 miles; the breadth of the interior ring is 20,000 miles; the breadth of the exterior is 7,000 miles, and the distance between the two, is 2,800 miles.

Saturn is attended by seven satellites, which move round him in orbits that nearly coincide with the plane of the ring, except that of the seventh, which makes a less angle with the ecliptic.

The satellites of Saturn can only be seen by telescopes of pretty high powers.

When Saturn's ring is in a favourable situation, it is one of the most pleasing of the heavenly bodies to view, as an object of curiosity.

URANUS AND ITS SATELLITES.

This planet was discovered by Dr. Herschel, in the year 1781, and was by him called *Georgian Sidus*, in honour of his sovereign and patron, George the third, of England. On the continent of Europe it was called *Herschel*, in honour of its discoverer; but it is now pretty generally obtaining the name of Uranus.

Uranus performs a siderial revolution round the sun in 30,689 days, or a little more than 84 years, at the immense distance of 1,800 millions of miles.

The diameter of Uranus is 35,000 miles, but owing to its great distance from the earth, it has not been ascertained whether it revolves on its own axis, or not.

According to the observations of Dr. Herschel, Uranus is attended by six satellites, which revolve round it in orbits nearly perpendicular to the Ecliptic.

VESTA, JUNO, CERES, AND PALLAS.

These four planets, though less distant from the sun than Jupiter, are so small, that they cannot be seen without the aid of good telescopes.

They revolve round the sun from west to east, in orbits that are contained between the orbits of Mars and Jupiter, and in the order in which they are named. The orbit of Pallas makes a greater angle with the plane of the ecliptic, than that of any other planet. This angle is nearly 35 degrees.

COMETS.

Comets are opaque, spherical bodies, like the planets, and they appear luminous by reflecting the light of the sun. They are but seldom seen, and they continue visible but a short time.

The appearance of a comet is generally that of a collection of thin luminous vapour, in the centre of which is a nucleus that is not, in general, very distinctly defined.

The comets revolve round the sun in very eccentric ellipses, of which the sun occupies one of the foci.

When a comet is first seen, it is generally surrounded with a faintly luminous vapour, which is called the *Coma*. As the comet approaches the sun, the coma becomes more bright, and at length shoots out into a long train of luminous semi-transparent vapour, in a direction opposite to the sun. This train is called the *Tail* of the comet.

The number of comets is unknown ; but it is supposed to amount to several hundred.

The only comet that is known with certainty to have reappeared, is one that was seen in 1682 and returned in 1759.

Comets are seen only when near the perihelion of their orbits.

OF THE TIDES.

From astronomical investigations, it appears that all the different bodies comprising the solar system, attract one another, more or less forcibly according to their distances and to the quantities of matter they respectively contain. The earth is retained in its orbit by a reciprocal attraction between it and the sun; and the moon by a similar attraction between it and the earth.

The forces of attraction which the sun and moon exert upon the earth, produce an alternate rise and fall in the waters of the ocean, and consequently in the bays, rivers, &c. which have a free communication with the ocean, twice in every lunar day. These are known by the name of *Tides*.

The moon, in consequence of its being so much nearer to the earth than the sun, is the more powerful agent in producing the tides. Hence the time of *high*, or *low* water at any particular place, always depends upon the situation of the moon with respect to that place.

The time of high water at any place in the open sea, is generally about two hours after the moon has passed the meridian of that place; but on the shores of the continents, or of some of the larger islands and where there are shallows and obstructions to the motion of the water, the interval between the passage of the moon over the meridian and the time of high water, is very different at different places. It may, however, be observed that, at any particular place, the interval between high water and the moon's passage over the meridian is always nearly the same.

In the open sea, high water occurs at the same time at places on the opposite sides of the earth, or that differ in longitude 180 degrees.

The tides that occur at the time of new or full moon, that is when the sun and moon are in the same, or in directly opposite directions, are the highest, and are called *Spring Tides*.

Those which occur about the time the moon is in the first, or last quarter, are lowest, and are called *Neap Tides*.

In the ocean the spring tides rise about twice as much as the neap tides; but in bays and rivers the difference is not, generally, so great.

The highest of the spring tides is generally the third after new or full moon, and the lowest of the neap tides, the third after first or last quarter.

The height of the tides varies with the moon's distance from the earth. The tides are higher, other circumstances being the same, when the moon is in perigee, than when it is in apogee.

From the time the water commences to rise, until it attains its full height, it is said to be *Flood Tide;* and from the time it commences to fall until low water, it is said to be *Ebb Tide.*

OF THE FIXED STARS.

There is so great a resemblance in appearance between the planets and the fixed stars, that a student, after having learned that the former are indebted to the sun for the light they transmit to us, might very naturally suppose that the latter derive their brilliancy from the same source. But from the most careful investigation it has been ascertained that the fixed stars are not rendered visible by reflecting the light of the sun, but by emitting light of their own.

If the angular distance between any two of the fixed stars, be taken, it will be found to be precisely the same, though the observations be made at places the most distant from each other. Hence it follows that their distance from us is so great, that the diameter of the earth, when compared with it, becomes entirely insensible.

It is estimated that *Sirius*, the *Dog Star*, which, from its apparent magnitude, is supposed to be the nearest of the fixed stars, cannot be less than *thirty-two million millions of miles* from the earth. And if this estimate be correct, it must require a period of at least 1949 days, or 5 years, 124 days, for a particle of light, which moves with the velocity of 190,000 miles per second, to traverse the distance between Sirius and the earth. If then Sirius were at this moment, to be annihilated, more than five years would elapse before we should be sensible of its disappearance, in the heavens.

Since the distance of the fixed stars is so inconceivably great, it follows that their magnitude must be immense, or they would not be visible. The probability is, that they are really suns, of no less magnitude than that which is the centre of our system, and that each is attended by a number of planetary worlds, that move round it as their centre, and derive heat and light from its rays.

The number of the fixed stars that are visible to the naked eye is, by no means, so great as the appearance of the heavens, on a clear night, would lead us to suppose. With the unassisted sight, we can, at no time, perceive more than about one thousand.

Most of the fixed stars partake of the apparent diurnal revolution of the heavens from east to west, and alternately rise and set. But if we direct our sight towards the northern part of the heavens, we may notice a number of stars that never go below the horizon, but describe circles about a certain star which appears to be stationary. The star about which these circles are described is called the *Polar Star*, and those that move round it without going below the horizon are called *Circumpolar Stars*.

The polar star does not remain entirely

stationary but describes a small circle about the north pole of the heavens.

The elevation of the polar star corresponds nearly with the latitude of the place; as we approach the equator its elevation diminishes, and the number of circumpolar stars is less; and as we approach the north pole, its elevation increases, and the number of circumpolar stars is greater. At the equator, the polar star is nearly in the horizon, and at the north pole, it is nearly in the zenith.

The ancients, in order to distinguish the different stars from each other, supposed the figures of beasts, birds, and other objects to be drawn on the concave surface of the heavens; and the group of stars contained within the contour of any such figure was called a *Constellation*, to which the name of the object, supposed to be described, was given; as *Ursa Major*, the *Great Bear*; *Aquila*, the *Eagle*; &c. This method of distinguishing the stars is still continued, and the number of constellations, has, of latter time, been considerably increased.

The different stars of any particular constellation are distinguished from each other by applying to them the letters of the Greek alphabet according to their apparent magnitude. The letter *Alpha* is applied to the most conspicuous; the letter *Beta* to that of second magnitude; *Gamma* to that of third magnitude; and so on. Thus we have the star *Alpha in Ursa Major,* the star *Beta in Aquila; &c.*

Some of the most conspicuous of the stars have particular names; as, Sirius, Aldebaran, Arcturus, Regulus, Lyra, Capella, Fomelhaut, &c.

The stars are also divided into classes according to their apparent magnitudes, independent of their arrangement in the constellations. Those of the first class are called *stars of the first magnitude;* of the second class, *stars of the second magnitude;* and so on to *stars of the sixth magnitude,* which are the smallest that can be seen with the naked eye.

The faintly luminous zone in the heavens, known by the different names of the *Galaxy* and the *Via Lactia* or *Milky Way,* is ascertained to be nothing but a vast assemblage of stars that are too minute to be distinctly seen without the aid of telescopes.

OF THE CALENDAR.

The *Calendar* is a distribution of time into periods of different lengths, as *Years, Months, Weeks,* and *Days.*

The tropical year, as has been stated, consists of 365 days, 5 hours, 48 minutes, and 52 seconds. But in reckoning time for the common purposes of life it is most convenient for the year to consist of a certain number of whole days, without any fractional parts. In the calendar established by Julius Cæsar, and thence called the *Julian Calendar,* three successive years were made to consist of 365 days each, and the fourth, of 366 days.

The year which contained 366 days was called *Bissextile,* or *Leap Year;* and the other three were called *Common Years.* The additional day in bissextile, or leap year, was called the *Intercalary Day.* These distinctions are continued in use at the present time.

The tropical year, according to the Julian calendar, is supposed to consist of exactly 365¼ days. A year of this length is called a *Julian Year.* The Julian year, therefore, exceeds the true astronomical year, by 11 minutes, 8 seconds. This difference amounts to a *day* in about 130 years.

At the time of the *Council of Nice*, which was held in the year 325, the vernal equinox occured on the 21st of March, according to the Julian calendar; but by the latter part of the sixteenth century, in consequence of the excess of the Julian year above the true solar year, it occured on the 11th of March; that is, 10 days earlier than in the year 325. Hence it was found that by continuing to reckon according to the Julian calendar, the seasons, in process of time, would occur at entirely different parts of the year. Summer would commence in December instead of June; and Spring would begin in September instead of March.

Pope Gregory XIII, finding that considerable inconvenience would arise from this progressive change, with respect to the times of holding certain feasts of the Catholic Church, took measures for preventing it. He ordered the day following the 4th of October 1582, to be called the 15th instead of the 5th, which would bring the vernal equinox on the 21st of March again in the following year. And to prevent any error in future, it was concluded that three intercalary days should be omitted in every four hundred years. The year 1600 was a bissextile; but the years 1700, 1800, and 1900, which according to the Julian calendar would be bissextiles, were to have no intercalary day.

The calendar thus improved, and which is now in general use, is called the *Gregorian Calendar.*

Time, reckoned according to the Gregorian calendar, agrees so nearly with that reckoned by true solar years, that the difference will not amount to a day in 4,000 years.

The calendar as improved by Pope Gregory, was immediately adopted in all the catholic countries of Europe; but in England and her colonies it was not adopted until the year 1782, when the difference amounted to more than 11 days. The Julian calendar, has, since that time, been called *Old Style,* and the Gregorian calendar, *New Style.* The former is still in use in Russia; and it now differs twelve days from New Style.

The year is divided into twelve portions called *Calendar Months,* which are distinguished by the names, January, February, March, &c. or by the numerical adjectives, First, Second, Third, &c. Each calendar month contains either thirty or thirty-one days, except February, which in common years, contains twenty-eight days, but in a bissextile, twenty-nine.

The days of the week were formerly designated by the first seven letters of the alphabet, always placing them so that A should correspond to the first day of the *Year*, B to the second, C to the third, D to the fourth, E to the fifth, F to the sixth, G to the seventh, A to the eighth, B to the ninth; and so on throughout the year. The letter designating the first day of the week, or Sunday, is called the *Dominical Letter*.

A bissextile has two dominical letters, one for January and February, and the other for the remaining months.

The *Solar Cycle* is a period of 28 years, in which, according to the Julian calendar, the days of the week return to the same days of the month, and in the same order, throughout the year.

The *Lunar Cycle* is a period of 19 years, in which the new and full moons return on the same days of the year.

The *Cycle of Indiction* is a period of 15 years which was instituted by the Roman emperor, Constantine, and had reference to certain judicial acts.

QUESTIONS FOR EXERCISING THE LEARNER ON THE PRECEDING DEFINITIONS AND OBSERVATIONS.

What is *Astronomy?*

What are the form and the size of the earth?

What is the *Axis* of the earth?

What are the *Poles* of the earth?

What are the *Poles* of the heavens?

What are the *Zenith* and *Nadir* of any place?

What is the *Sensible Horizon* of any place?

What is the *Rational Horizon* of any place?

What are those circles called which pass through the celestial poles?

What is the *Meridian* of any place?

What are those points called where the meridian cuts the horizon?

What is a *Meridian Line* or *Terrestrial Meridian?*

What is the *Celestial Equator?*

What is the *Terrestrial Equator?*

What are those circles called that pass through the zenith and nadir of any place?

What is the *Prime Vertical?*

What are those points called where the prime vertical cuts the horizon?

What is the *Latitude* of a place? and how is it reckoned?

What are *Parallels of Latitude?*

What is meant by the *First Meridian?*

What is the *Longitude* of a place? and how is it reckoned?

What is a *Solar Day?*

How is the solar day divided?

What is a *Siderial Day?*

What is the length of the Siderial day in solar time?

Are clocks and watches regulated to correspond with solar, or siderial time?

When does the *Astronomical* day begin?

When does the *Civil* or *Common* day begin?

What is that circle called which the sun appears to describe among the stars?

What are the *Equinoctial Points?*

What part of the ecliptic is on the north side of the equator? and what on the south?

What is the *Vernal Equinox?* and what is the *Autumnal Equinox?*

Have the terms, *Vernal* and *Autumnal Equinox* any other significations?

Into how many parts is the ecliptic supposed to be divided? and what are they called?

Where does the division of the ecliptic commence? and in what direction are the signs numbered?

What are the names of the signs in their proper order?

What is a *Tropical Year?*

What is the exact length of the tropical year?

What are the *Solstitial Points?*

What are the *Summer* and *Winter Solstices?*

How great an angle does the plane of the ecliptic make with that of the equator? and what is that angle called?

How much more is the sun elevated when on the meridian at the summer solstice, than at the winter solstice?

What are the *Tropics?* and how are they distinguished from each other?

What are the *Polar Circles?* and how are they distinguished from each other?

Into how many *Zones* is the earth divided? and what are they called?

What is a *Circle of Latitude?*

What is the *Latitude* of any heavenly body?

What is the *Longitude* of a heavenly body?

What is the *Declination* of a heavenly body?

What is the *Right Ascension* of a heavenly body?

Where are the days and nights always equal? and where are they constantly varying?

At what time are the days and nights equal at all places on the earth?

When are the days longer than the nights? and when are they shorter, in the northern hemisphere?

When are the days longer than the nights in the southern hemisphere? and when shorter?

At what places does the sun make a complete revolution at the summer solstice without descending below the horizon?

Does it make a complete revolution at the winter solstice without going below the horizon? and if it does, at what places?

What change is there in the length of the days between the polar circles and the poles?

Into how many seasons is the year divided in the temperate zones? and what are the names of those seasons?

When does each of those seasons commence and end?

How does the inclination of the ecliptic to the equator, produce an effect upon the seasons?

Does the greatest heat of summer generally occur at the summer solstice when the sun has the greatest elevation, and the days are longest?

Does the greatest cold in winter generally occur before, or after the winter solstice?

How are the *Fixed Stars* distinguished from the *Planets?*

What is the number of planets? and what are their names?

Is the motion of the sun and the planets among the fixed stars *real*, or imaginary?

What is the cause of the sun's apparent motion among the stars?

To what class of the heavenly bodies does the earth belong?

What are the *Secondary Planets* or *Satellites?*

How many satellites are there? and about what planets do they revolve?

What are Comets? and how may they be distinguished from the stars and planets?

What bodies are comprised in the *Solar* System?

How are the planets and satellites rendered visible to us?

How does the appearance of the planets when viewed with a telescope, differ from that they present when viewed with the naked eye?

What is the diameter of the sun? and how much larger is it than the earth?

How long is the sun in performing a revolution on its axis?

What is the *Orbit* of a planet or satellite?

What are those points called in which the orbit of a planet or satellite cuts the plane of the ecliptic?

Which is the *Ascending Node?* and which the *Descending?*

What is the form of the figure included by the orbit of a planet? and what part of that figure does the sun occupy?

What is the *Zodiac?*

What are the *Perihelion* and *Apheiion* of a planet's orbit?

When is a planet or satellite said to be in *Conjunction?* and when in *Opposition?*

What is the *Synodic Revolution* of a planet?

What is the *Siderial Revolution* of a planet?

Which of the planets are the first in order receding from the sun? and why can they not be in opposition?

When are Mercury and Venus said to be in *Inferior Conjunction* and when in *Superior?*

What phenomenon is produced if Mercury or Venus is at or very near one of its nodes at the time of inferior conjunction?

In what years will the next four transits of Mercury occur? and in what country will all of them be visible?

When did the last two transits of Venus occur? and when will the next two occur?

What calculations have astronomers been enabled to make from observations on the transits of Venus?

In what time does Mercury perform a siderial revolution? and at what distance from the sun?

What is the diameter of Mercury? and what is its magnitude, compared with that of the earth?

What is Mercury's greatest angular distance from the sun? and when can it be seen?

Does Mercury revolve on its axis?

In what time does Venus perform a siderial revolution? and at what distance from the sun?

How long is Venus in performing a synodic revolution?

What is the diameter of Venus? and in what time does it revolve on its axis?

What is the greatest angular distance of Venus from the sun?

When is Venus *Evening Star*? and when *Morning Star?*

What changes in appearance does Venus undergo? and what are those changes called?

How long is it in passing through a series of those changes?

When is Venus the most brilliant?

Can it ever be seen in the day time? and if it can, when?

Does Mercury undergo any changes in appearance similar to those of Venus?

What is the exact form of the earth? and how much greater is the *equatorial,* than the *Polar* diameter?

What is the mean distance of the earth from the sun?

What is the eccentricity of the earth's orbit?

How much nearer is the earth to the sun, when in perihelion, than when in aphelion?

Have we our warmest, or our coldest weather when the earth is nearest the sun?

What is the inclination of the earth's axis to the plane of its orbit?

What is meant by *Apparent Time?*

What is meant by *Mean Time?*

How are *mean* and *apparent* time denoted?

What is the difference between mean and apparent time, called?

When is the equation of time greatest? and what is its amount at that time?

What is meant by the earth's *Atmosphere?*

What offices does it perform in the regular operations of nature?

Is the density of the atmosphere the same at different heights from the earth's surface?

Is it known to what height the atmosphere extends?

Does a ray of light suffer any change in direction by passing obliquely from one medium to another of different density?

What kind of line will a ray of light describe in passing obliquely through a medium whose density gradually increases or diminishes?

What is this change in the direction of a ray of light called?

What effect does refraction produce upon the apparent altitudes of the heavenly bodies?

When is the difference between the real and apparent altitudes greatest?

Is the sun, or any other of the heavenly bodies above, or below the horizon when it first come into view in the east?

Why does not the darkness of night commence immediately after the sun has descended below the horizon and disappeared?

What is the *Crepusculum* or *Twilight* ?

How far below the horizon is the sun when twilight ends in the evening or commences in the morning?

When is the twilight longest at places north of the equator?

When is the twilight shortest in the latitude of 40 degrees north? and when, in the latitude of 60 degrees north?

Is the duration of twilight less, or greater, at the equator than in high latitudes?

What is the mean distance of the moon from the earth?

What is the length of the moon's diameter?

How much less is the moon than the earth?

How great is the eccentricity of the moon's orbit?

In what angle does the moon's orbit cut the plane of the ecliptic?

What are those points called in which the moon's orbit, cuts the plane of the ecliptic?

What is that point in the moon's orbit called that is nearest to the earth? and that which is furthest from the earth?

What is that line called which joins the perigee and apogee of the moon's orbit?

How much nearer is the moon to the earth when in perigee, than when in apogee?

In what time do the moon's nodes make a revolution?

In what time do the apsides of the moon's orbit make a revolution?

How long is the moon in performing a *Siderial* Revolution?

In what time does the moon revolve on its own axis?

What is meant by a *Lunar Day?* and what is its length?

When is it said to be *New Moon?*

What is it that renders the more obscure part of the moon visible, when it is first seen after new moon?

When is the moon said to be in *First Quarter?*

What is the form of the luminous segment of the moon at first quarter?

When is it said to be *Full Moon?*

How many days elapse between new, and full moon?

When is the moon said to be in *Last Quarter?*

How long after new moon, does the last quarter occur?

What is meant by a Lunation or *Lunar Month?*

What is the length of a lunar month?

What phenomenon occurs at the time of new moon, when the moon is at or near one of its nodes?

What phenomenon occurs at the time of full moon, when the moon is at or near one of its nodes?

What is meant by an *Occultation* of a star or planet?

When is the moon's apparent diameter least? and when greatest?

When is the sun's apparent diameter least? and when greatest?

The *real* diameter of the sun is much greater than that of the moon, but their *ap-*

parent diameters are nearly the same. What is the cause of this?

Under what circumstances can a *Total Eclipse* of the sun occur?

What is an *Annular Eclipse?* and under what circumstances does it occur?

When will the next annular eclipse occur at Philadelphia?

Under what circumstances does a partial eclipse of the sun occur?

When the sun is totally or partially eclipsed at one place, is it eclipsed at all places where it is above the horizon at that time?

Does an eclipse of the sun present the same appearance at all places where it is visible?

To what distance does the conical shadow of the earth extend?

What is the diameter of a circular section of the earth's shadow, at the distance of the moon from the earth?

Under what circumstances may a total eclipse of the moon occur?

What is the distance of the moon from the earth when in perigee? and what when in apogee?

Why must the moon be nearer the node, to be eclipsed, when in apogee than when in perigee?

Do eclipses of the moon vary in magnitude as seen from different places?

Why do not eclipses of the moon vary in appearance as much as those of the sun, when viewed at different places?

How are we enabled to see the moon when it is totally eclipsed?

For what length of time, and with what degree of accuracy can eclipses be foretold?

What inference may be drawn from this with respect to our knowledge of the magnitudes and distances of the heavenly bodies?

At what time must an eclipse of the sun take place?

At what time must an eclipse of the moon occur?

Why do not eclipses occur at every new and full moon?

What is the greatest, and what the least number of eclipses that can occur in a year?

What is the average number of eclipses in a year?

When seven eclipses occur in a year, how many of them are of the sun?

What is the least number of eclipses of the sun that can occur in a year?

Why are there more eclipses of the moon than of the sun, visible at any given place?

What is the greatest possible duration of an eclipse of the sun at Philadelphia?

What is the greatest duration of an annular, and what of a total, eclipse of the sun?

What is the greatest duration of an eclipse of the moon, at any one place?

What is the greatest duration of a total eclipse of the moon at any place?

How is the quantity of an eclipse estimated?

Which are the *Inferior*, and which the *Superior Planets?*

Do the superior planets present the same phases as the inferior?

In what time, and at what distance from the sun does Mars perform a siderial revolution?

At what time does Mars appear largest?

What is the diameter of Mars? and what its magnitude compared with the earth?

In what time does Mars revolve on its axis?

By what may Mars be distinguished from the other planets?

In what time, and at what distance from the sun does Jupiter perform a siderial revolution?

What is the diameter of Jupiter, and what its magnitude compared with the earth?

In what time does Jupiter revolve on its axis?

What is meant by the *Belts* of Jupiter? and what position have they?

Do the satellites of Jupiter keep the same positions with respect to the planet, as seen from the earth?

How are the satellites of Jupiter distinguished from one another?

From what causes do the satellites of Jupiter become invisible?

To what important discovery have the eclipses of Jupiter's satellites led?

How long is light in passing from the sun to the earth?

What is the velocity of light per second?

To what useful purpose may the eclipses of Jupiter's satellites be applied?

In what time, and at what distance from

the sun does Saturn perform a siderial revolution?

What is the diameter of Saturn? and in what time does it revolve on its axis?

When viewed with a telescope, how can Saturn be distinguished from the other planets?

Is the ring of Saturn detached from the planet, or joined to it?

Under what form does the ring of Saturn appear, when in its most favourable situation?

From what causes may Saturn's ring become invisible?

Is Saturn's ring entire, or is it composed of several parts?

What is the distance of the interior ring from the centre of the planet?

What is the distance between the rings? and what the breadth of each?

How many satellites has Saturn?

When, and by whom was the planet Uranus discovered?

What other names has it had?

In what time and at what distance from the sun does Uranus perform a siderial revolution?

What is the diameter of Uranus?

Does Uranus revolve on its axis?

By what number of satellites is Uranus attended?

Between what two of the larger planets do Vesta, Juno, Ceres, and Pallas perform their revolutions?

What appearance does a Comet generally present?

In what kind of orbits do the comets revolve round the sun?

What is the general appearance of comets when first seen? and what change do they undergo?

What comet is known with certainty to have reappeared?

In what part of their orbits are comets when they are visible?

How are the earth and moon retained in their orbits?

What is the cause of the *Tides?*

Upon what does the time of high water at any particular place, depend?

When is it high water in the open sea?

How must places be situated with respect to each other in the open sea, to have high water at the same time?

When are the tides highest? and what are they then called?

When are the tides lowest? and what are they then called?

What is the difference in height between spring and neap tides, in the ocean?

Has the difference in distance of the moon from the earth any effect upon the height of the tides?

Which is, generally, the highest of the spring tides? and which is the lowest of the neap tides?

What is meant by the terms, *Flood Tide* and *Ebb Tide?*

Do the fixed stars appear luminous by reflecting the light of the sun? or by emitting light of their own?

What is the estimated distance of Sirius from the earth?

If this estimate be correct how long would it require for a particle of light to pass from Sirius to the earth?

If Sirius were this moment to be annihilated, how long would it be before we should be sensible of it?

What is the probability with respect to the nature and purpose of the fixed stars?

What number of fixed stars is visible, at any one time, to the naked eye?

What difference, with regard to their motions, do we discover between the stars towards the north, and those in other parts of the heavens?

What is that star called which appears to be stationary?

What are those stars called that do not rise and set?

Is the Pole star entirely stationary?

Are the number of circum-polar stars and the elevation of the Pole star the same at all places on the earth's surface?

In what way are the stars in different parts of the heavens distingushed from each other?

How are the stars of any particular constellation distinguished from one another?

Are the more conspicuous stars distinguished in any other way?

What is the occasion of that luminous appearance in a part of the heavens, known by the name of the *Galaxy* or *Milky Way?*

What is the *Calendar*?

What is the *Julian Calendar?*

How does a *Bissextile* differ from a *Common Year?*

What is the added day in a bissextile called?

What difference is there between a true tropical year, and a year according to the Julian calendar?

What inconvenience would this error, or difference produce?

What is the difference between the Julian and Gregorian calendars?

How many years would elapse before the error of a single day would accumulate according to the Gregorian calendar?

When was the Gregorian calendar adopted on the continent of Europe? and when in England?

What is meant by the terms, *Old Style* and *New Style?*

In what country is the Julian calendar still in use? and what is the difference between the time as reckoned there, and as reckoned according to the Gregorian calendar?

What is meant by the *Dominical Letter?*

Has any year more than one dominical letter?

What is the *Solar Cycle?*
What is the *Lunar Cycle?*
What is the *Cycle of Indiction?*

OF THE GLOBES.

For the common purposes of geography, it is usual to represent the surface of the earth on a plane. But, as the earth is nearly spherical in its form, no representation on a plane surface, can give so accurate an idea of the relative situations of the different countries, oceans, islands, cities, &c. as can be given by delineating them on the surface of a sphere, according to their situations on the earth. It is true, the earth is not a perfect sphere, the equatorial diameter being about 25 miles greater than the polar diameter, as was stated in the observations on astronomy. The earth is also diversified with mountains and valleys, which form a very irregular surface, compared with the extent of our view, even when we are placed in the most favourable situations. But this difference in the diameters, and these irregularities in the surface of the earth, are so exceedingly small, compared with the whole magnitude of the earth, that they would scarcely be perceptible even on a globe of six feet diameter. The difference in the diameters would be less than one fourth of an inch, and the representation of the highest mountain, would be smaller than an ordinary grain of sand. If the sphere be reduced to one third, or one fourth of this diameter, which is more nearly the size of ordinary globes, these irregularities would entirely disappear, and the difference between the polar and the equatorial diameters would not be appreciable. Hence we may conclude that, without extending it to an unmanageable size, a perfect sphere is the most accurate representation that can be given of the figure of the earth.

The artificial sphere or globe is constructed in the following manner.—A spherical block or mould of wood, somewhat less than the size of the intended globe is prepared, and on it are laid successive coverings of paper or pasteboard, attached to one another by glue or paste till the whole is about one tenth of an inch in thickness. When completely dry, this covering is cut into two hemispheres, and is then easily separated from the mould. These hemispheres being placed on a wooden axis, representing the polar diameter, are stitched together in the same position as when attached to the mould. In the extremities of the wooden axis, are fixed pins of iron or some other metal, which represent the poles, and by which the whole is suspended in a metallic semicircle whose diameter is exactly equal to that of the intended globe. In this state, a composition of whiting and glue is applied to the surface of the paper, the globe in the mean time being made to revolve, so that the inner edge of the semicircle, which is prepared for the purpose, pares off the superfluous plaster from the projecting parts of the surface. The whole being thus made perfectly smooth and spherical, and at the same time so balanced on its axis, as to remain in any position it may be placed when suspended by the poles, it is set aside to dry and harden; after which it is ready to receive the different circles that are supposed to be drawn on the earth's surface, as well as a delineation of the different continents, islands, and oceans. The manner in which these are applied to it, will be described hereafter. The iron pins in the extremities of the axis, formerly used for fixing the globe in the metallic semicircle, are now employed to suspend it in a brass circle of such a diameter that the globe may just have room to revolve in it, without coming in contact with any part of its interior edge. This ring of brass is called the *Universal Meridian,* because by turning the globe it may be made to represent the meridian of any place. The top of the frame in which the globe is placed, always consists of a broad horizontal ring of wood of which the interior diameter is just equal to the interior diameter of the brazen meridian. The latter with the globe suspended in it, passes through notches in the horizontal ring, and rests by its under edge in a metallic groove in which it may be made to slide, so as to elevate or depress the poles, at pleasure. In every position, however, one half the globe is above, and the other half below the upper surface of the horizontal ring. This surface, then, represents the *Rational Horizon.*

On the surface of the rim representing the rational horizon, several concentric circles are described and variously divided, according to the purposes which they are intended to serve. That towards the outer edge of the rim, is called the *Calendar*. It is divided into 365 equal parts, representing the days in the year, classed under their respective months, and so arranged that the 20th of March, exactly corresponds with the east point of the horizon. The next circle represents the *Ecliptic* divided into signs and degrees, and so arranged that the first point in *Aries* corresponds with the 20th of March in the calendar, which brings each point of the ecliptic opposite to the day on which the sun is at that point. The names and characters of the different signs are placed opposite the middle of each.

The next circle represents the horizon divided into 32 equal parts, representing the points of the mariner's compass. And the innermost circle represents the horizon divided into quadrants, and these quadrants each into 90 degrees. Two of them are numbered from the east and two from the west towards the north and south.

The brazen or universal meridian is divided into degrees, reckoning in two of the quadrants from the equator towards the poles, and in the other two from the poles towards the equator, each quadrant being numbered from one to ninety. Two of these quadrants are used for ascertaining the latitudes of places on the globe, and the other two for raising either of the poles a certain number of degrees.

The circle representing the *Equator* is also divided into degrees in two directions, beginning at the first meridian, which, on British globes, is that of the royal observatory at Greenwich, near London, and extending to 180 degrees. This is used for ascertaining the longitudes of different places on the globe. Besides the first meridian, 23 others are drawn on the globe, intersecting the equator in every fifteenth degree.

The *Ecliptic* is generally made to intersect the equator and first meridian in the same point, the angle which it forms with the equator being 23 degrees and 28 minutes. It is divided into 12 signs, and each sign is subdivided into 30 degrees, and reckoned eastward from the first meridian. The characters of the signs are placed at the beginning, or opposite the middle of each.

Parallel to the equator, and at the distance of 23 degrees, 28 minutes from it are drawn two circles representing the *Tropics* of *Cancer* and *Capricorn*. Parallel to the tropics, and at the distance of 23 degrees, 28 minutes from the poles, two other circles are drawn, representing the *Arctic* and *Antarctic Circles*.

Parallels of Latitude are also drawn intersecting the meridians in every tenth degree, on both sides of the equator.

Such is a general view of the artificial globe usually employed to represent the earth. It is called the *Terrestrial Globe* to distinguish it from that used to represent the heavens, which is denominated the *Celestial Globe*.

The celestial globe, like the terrestrial, is suspended by the poles in a brazen meridian, and mounted in the same way in a horizon. On its surface are described the equator, the ecliptic, the tropics, the polar circles, the equinoctial and solstitial colures, circles of celestial longitude, and parallels of celestial latitude. The brazen meridian and the ecliptic are divided in the same way as on the terrestrial; but the degrees of the equator are réckoned only in one direction, viz. towards the east. On the surface of the celestial globe the fixed stars are represented in their true relative situations, distinguished according to their apparent magnitudes, and arranged in constellations.

Besides the parts already described, there are the *Horary* or *Hour Circle*, and the *Quadrant of Altitude*, that are appendages to both globes.

The *Horary* is a small brass circle fixed with its centre on the north pole of the globe, and divided into 24 equal parts, representing the hours of the day. The divisions are reckoned from 1 to 12 along the first semicircle, and again from 1 to 12 on the other, commencing at the opposite point from the first. The circle is moveable by the hand, so that any hour may be brought to the brazen meridian; but when left to itself it turns with the globe.

The *Quadrant of Altitude* is a graduated slip of brass, so thin and flexible as to be easily applied to the surface of the globe. It is furnished at one end with a screw by which it may be attached to any part of the brazen meridian. When this extremity is fixed on the zenith of the globe, the commencement of the graduation coincides with the horizon, and the part between that and the zenith is divided into 90 degrees. The graduation is also continued to the other extremity which is generally 18 or 20 degrees below the horizon.

The delineation of the different circles on the two globes, and of the different continents, oceans, islands, &c. on the terrestrial globe, and of the constellations and particular stars on the celestial, is performed in the following manner: Strips of paper, called *gores*, are cut, having the form of the space that would be contained between two meridians drawn on the globe, a few degrees apart. On these gores are delineated separate portions of the earth or heavens, according as they are intended for a terrestrial, or celestial globe. They are afterwards fixed in order on the surface of the globe, prepared in the manner that has already been described, by paste or some other adhesive substance. When they are thus fixed, the whole is covered with a transparent varnish, to prevent it from being easily soiled or otherwise injured.

When perusing the terrestrial globe the eye of the observer is in its natural position, but when he is examining the celestial, he he must conceive himself to be placed in the centre, and looking towards the concave surface.

SOLUTIONS OF PROBLEMS BY THE TERRESTRIAL GLOBE.

PROBLEM I.

To find the Latitude and Longitude of any place on the earth's surface.

Turn the globe until the given place is exactly under the graduated edge of the brazen meridian; then the degree of the meridian over the place will be its *latitude*, and the point of the equator intersected by the same edge of the meridian will be its *longitude*.

EXAMPLES.

What is the latitude, and the longitude of Philadelphia?

Ans. Lat. 40° N. Long. 75¼° W. nearly.

What is the latitude, and the longitude of Paris?

Ans. Lat. nearly 49° N. Long. 2° 20′ E.

What is the latitude, and the longitude of Lima, in Peru?

What is the latitude, and the longitude of Canton, in China?

Note.—As the degrees on the meridian and equator are small, the latitudes and longitudes in these examples, are not generally given nearer than to quarters of a degree.

PROBLEM II.

The latitude and longitude of a place being given, to find the place on the globe.

Find the given longitude on the equator, and bring it to the graduated edge of the brazen meridian; then the place will be under the degree of the meridian denoting the latitude.

EXAMPLES.

The latitude of a certain place is 30° N. and its longitude 31¼° E.; what is the place?

Ans. Cairo.

The latitude of a place is 40° N. and its longitude 116½° E.; what is the place?

Ans. Pekin.

What island is situated in latitude 33¾° S. and longitude 79° W.?

Ans. Juan Fernandez.

What city is situated in latitude 23° north, and longitude 89¾° east?

PROBLEM III.

To find the difference of latitude, and the difference of longitude between two places.

Find the latitudes of both places by Problem I. and take their difference, or sum, according as they are on the same side, or on different sides of the equator. The difference of longitude is found in the same way, by taking the difference, or sum of the longitudes, according as they are on the same side or on different sides of the first meridian.

EXAMPLES.

What is the difference of latitude, and the difference of longitude, between Philadelphia and Hamburg?

Ans. Diff. of Lat. 13½°; Diff. of Long. 85°.

What is the difference of latitude and the difference of longitude between Quebec and the Cape of Good Hope?

Ans. Diff. of Lat. 80¾°; Diff. of Long. 89½°.

What is the difference of latitude and the difference of longitude, between Petersburg, in Russia, and Valparaiso, in Chili?

What is the difference in latitude and the difference of longitude, between Dublin and New Orleans?

PROBLEM IV.

The hour being given at one place, to find the hour at any other place at the same time.

Bring the given place to the meridian and set the horary to the given hour; then turn the globe from east to west till the place at which the hour is required comes to the meridian, and the hours that pass under the meridian, will be the difference in time between the two places. If the place at which the hour is required is east of that at which it is given, add this difference to the given time, but if the place is west, subtract the difference from the given time.

EXAMPLES.

When it is six o'clock in the morning at

Philadelphia, what is the time at London, and what at Vienna?

Ans. 11 o'clock at London; 5 minutes past 12 at Vienna.

When it is 10 o'clock in the evening at Petersburg in Russia, what time is it at Boston, and also at New Orleans?

Ans. 3 o'clock 15 minutes, afternoon, at Boston; 2 o'clock, afternoon, at New Orleans.

When it is six o'clock in the morning of the 21st of May, at Savannah, what time is it at Pekin, in China?

When it is four o'clock, P. M. at Philadelphia, what time is it at Berlin, on the 15th of January?

PROBLEM V.

To find the distance between two given places on the earth in statute miles.

Apply the graduated edge of the quadrant of altitude to the two places, and observe the number of degrees intercepted between them; these degrees multiplied by 69 will give the number of miles, *nearly*.

EXAMPLES.

What is the distance between London and Philadelphia? *Ans.* 3019 miles.

What is the distance between Philadelphia and Lima? *Ans.* 3590 miles.

What is the distance between Edinburg and New Orleans?

What is the distance between Boston and Cape Horn?

PROBLEM VI.

To find the sun's Longitude and Declination on any given day in the year.

Find the given day in the calendar on the horizon and opposite to it in the ecliptic will be the sun's *longitude,* commonly called the *sun's place.* Find this longitude in the ecliptic marked on the surface of the globe, and bring it to that part of the brazen meridian in which the degrees are numbered from the equator towards the pole; then the number of degrees intercepted between this point and the equator will be the sun's *declination.*

EXAMPLES.

What is the sun's longitude and declination on the 15th of April?

Ans. Long. 26°; Declin. 10° north.

Required the sun's place and declination on the following days:—January 21st, February 8th, June 15th, August 12th, December 1st.

PROBLEM VII.

To find those places in the torrid zone, to which the sun will be vertical, on any given day.

Find the sun's place in the ecliptic and bring it to the brazen meridian; mark the degree of the meridian over it; then all the places that pass under that degree while the globe is revolving will have the sun vertical on that day.

EXAMPLES.

At what places is the sun vertical on the following days? viz. April 25th, June 6th, September 2nd, December 11th.

PROBLEM VIII.

The day and hour being given at any place, to find where the sun is then vertical.

Find the sun's declination, by Prob. VI. and mark it on the brazen meridian; bring the place and hour to the brazen meridian; then, if the hour is before noon, turn the globe westward, but if after noon turn it eastward until the 12th hour of the horary comes to the brazen meridian, and the place where the sun is vertical will be under the degree denoting the sun's declination, marked on the meridian.

EXAMPLES.

When it is two o'clock in the morning on the 25th of April, at Boston, where is the sun vertical?

Ans. At Madras.

When it is twenty minutes past five P. M. on the nineteenth of May, at Philadelphia, where is the sun vertical?

Ans. At Owhyhee.

When it is a quarter past six o'clock in the morning, at London, on the 10th of June, where is the sun vertical?

PROBLEM IX.

To find the sun's meridian altitude at any place, on any given day.

If the given place is north of the equator, elevate the north pole of the globe as many degrees as the place is north of the equator; but if the place be in south latitude, elevate the south pole as many degrees as are denoted by the latitude of the place; then find the sun's place for the given day and bring it to the brazen meridian; the number of degrees of the meridian, intercepted between the sun's place and the horizon, will give the sun's meridian altitude.

EXAMPLES.

What is the sun's meridian altitude at Philadelphia on the twenty-first of June?

Ans. 73° 28′.

What is the sun's meridian altitude at Boston on the twentieth of March?

Ans. 48° 28′.

What is the sun's meridian altitude at Petersburg, in Russia, on the twenty-first of December?

What is the sun's meridian altitude at Manilla, on the tenth of April?

PROBLEM X.

The day and hour being given at any place, to find all those places where the sun is rising, those where the sun is setting, and those that have noon.

Find the sun's declination for the given time, and elevate the north or south pole, according as the declination is north or south, until the number of degrees above the horizon is equal to the declination. Bring the given place and hour to the meridian, and turn the globe towards the west or east, according as the hour is before or after noon, until 12 of the hour circle be under the meridian. To all the places in the western side of the horizon the sun is rising; to those in the eastern side he is setting; and to those under the brazen meridian it is noon.

EXAMPLES.

On the 20th of March at 1 o'clock P. M. at Philadelphia, where is the sun rising? where is he setting? and where is it noon?

Ans. The sun will be rising a little west of Bhering's strait and the Friendly islands; setting at London, Havre de Grace, Alicant, and the Gold Coast of Africa; and it will be noon at New Orleans, the Bay of Honduras, and the Gallipagos Islands.

When it is 11 o'clock A. M. at Philadelphia, on the 25th of April, where is the sun rising, setting, &c.?

PROBLEM XI.

To find the time of the sun's rising or setting, on any day, at any place whose latitude is not greater than 66° 32′.

Elevate the pole according to the latitude of the place, as in Prob. IX. and bring the sun's place in the ecliptic, as well as the 12th hour of the horary to the meridian. Then turn the globe eastward until the sun's place comes to the horizon, and the hour under the meridian will be the time of sun-rising. In like manner, by turning the globe westward until the sun's place is in the horizon, we have the hour of sun-setting under the meridian.

EXAMPLES.

At what time does the sun rise and set at Charleston, South Carolina, on the 20th of June?

Ans. Rises at 5 o'clock, Sets at 7 o'clock.

At what time does the sun rise and set at Petersburg, Russia, on the 21st of December?

Ans. Rises ¼ past 9 o'clock, Sets ¼ before 3 o'clock.

At what time does the sun rise and set at Tornea, at the head of the Gulf of Bothnia, on the 21st of June?

At what time does the sun rise and set at Philadelphia, on the twentieth of April?

PROBLEM XII.

To find the length of any day or night at any place whose latitude does not exceed 66° 32′.

Find the hour of sun rising and setting by Prob. XI. Double the time of sun-rising, and it will give the length of the night; double the time of sun-setting, and it will give the length of the day.

EXAMPLES.

What is the length of the 21st day of June, and also of the night succeeding it, at Edinburg?

Ans. Length of the day, 17½ hours; length of the night, 6½ hours.

What is the length of the day on the 21st of December, at Stockholm?

Ans. 5½ hours.

What is the length of the night, on the 25th of May, at Skalholt, in Iceland?

What is the length of the day at Boston, on the first of April?

PROBLEM XIII.

To find the length of the longest day in the north Frigid Zone.[*]

Elevate the north pole equal to the latitude of the given place; then, in turning the globe, observe what points of the ecliptic cut the north point of the horizon. Find those points in the ecliptic, delineated on the horizon, and opposite to them in the calendar, will be the days on which the longest day at the given place begins and ends. The one preceding the 21st of June will denote the beginning, and that following it, the end.

EXAMPLES.

What is the length of the longest day at the North Cape, in the island of Maggeroe, in latitude 71° 30′ north?

---

[*] When we speak of the longest day in either of the frigid zones, we mean the time during which the sun is continually above the horizon. At the poles it is one half the year.

Ans. It begins on the 14th of May, and ends on the 30th of July. It is therefore seventy-seven days long.

What is the length of the longest day at the northern extremity of Nova Zembla, in latitude 77° north?

PROBLEM XIV.

To find the length of the longest night at any place in the north frigid zone.

Elevate the north pole, as in Prob. XIII. and turning the globe, observe what points of the ecliptic cut the south point of the horizon. Then find the corresponding points in the ecliptic on the horizon, and the days in the calendar opposite to these points will be those on which the longest night begins and ends. That preceding the 21st of December will be the beginning, and that following it, the end.

EXAMPLES.

What is the length of the longest night at the North Cape, in the island of Maggeroe, in Lat. 71° 30′ north?

Ans. The longest night commences on the 16th of November, and ends on the 27th of January; it is therefore 73 days long.

What is the length of the longest night at the northern extremity of Nova Zembla, in Lat. 77° north?

What is the length of the longest night in the island of Spitsbergen, in Lat. 80° north?

PROBLEM XV.

To find the beginning, end, and duration of twilight, at any place, on any given day.

Elevate the north or south pole according to the latitude of the place, as in Prob. IX. find the sun's place in the ecliptic, bring it and the 12th hour of the horary to the brass meridian, and screw the quadrant of altitude to the brass meridian at the given latitude; turn the globe westward until the sun's place comes to the horizon, and the index will show the time of sun-setting, or beginning of twilight: continue the motion westward until the sun's place coincides with 18° below the horizon, on the quadrant of altitude; the horary will then show the end of twilight; subtract the time of sun-setting from this, and we have the duration of twilight. Morning twilight may be found nearly in the same manner as the evening, by turning the globe eastward; its length is the same on the same day.

EXAMPLES.

Required the beginning, end, and duration of evening twilight at London, on the 19th of April.

Ans. It begins two minutes past seven; ends nineteen minutes past nine; duration two hours and seventeen minutes.

Required the beginning, end, and duration of evening twilight at Edinburg on the 21st of March.

Required the beginning, end, and duration of morning twilight at Cape Horn, on the 1st of April.

As twilight does not end in the evening until the sun has descended 18° below the horizon, it follows that at all places whose north latitudes are greater than 48½° there will be one or more nights about the 21st of June on which twilight will continue the whole night, although those places may not be in the north frigid zone.

PROBLEM XVI.

Any place whose latitude is greater than 48° 30′ being given, to find the beginning, end, and duration of constant twilight, agreeable to the preceding observations.

Find the latitude of the given place and add 18° to that latitude; count the number of degrees corresponding to this sum, on that part of the brass meridian which is numbered from the pole towards the equator, and mark where the reckoning ends; make the globe revolve upon its axis and observe the points of the ecliptic that pass under the mark on the meridian; find the same degrees in the ecliptic on the horizon, and the days corresponding to them will be those on which constant twilight begins and ends.

EXAMPLES.

When does constant twilight begin at London, and how long does it continue?

Ans. It begins the 22nd of May, and ends the 21st of July.

When does constant twilight begin, and how long does it continue, in the Shetland islands?

What is the duration of constant twilight at Edinburg.

SOLUTIONS OF PROBLEMS BY THE CELESTIAL GLOBE.

PROBLEM I.

To find the right ascension and declination of the sun, or of a star?

Bring the sun's place, or the star to that part of the brass meridian which is numbered from the equator towards the poles; the degree on the brass meridian will be the declination; and the degree of the equator under the graduated edge of the meridian will be the right ascension.

EXAMPLES.

Required the right ascension and declination of the star *Dubhe* in Ursa Major.

Ans. Right ascension, 162° 49′, Declination, 62° 48′ north.

What is the right ascension and declination of the sun on the second of June?

Ans. Right ascension, 71°; Declination, 22° N.

What is the right ascension and declination of *Sirius* in Canis Major?

Required the right ascension and declination of *Aldebaran*, in Taurus.

PROBLEM II.

To find the latitude and longitude of a given star.

Place the upper extremity of the quadrant of altitude on the north or south pole of the ecliptic, according as the given star is north or south of the ecliptic, and let its graduated edge fall upon the star; then the degree of the ecliptic intersected by the quadrant, will be the longitude of the star, and the degree of the quadrant over the star will be its latitude.

EXAMPLES.

Required the latitude and longitude of *Aldebaran*, in Taurus.

Ans. Latitude 5° 28′ south, Longitude 2 signs 6° 53′.

Required the latitude and longitude of *Antares*, in Scorpio.

Ans. Latitude 4½° south, Longitude 8 signs 6½°.

Required the latitude and longitude of *Alpheca,* in Corona Borealis.

What is the longitude and latitude of Capella, in Auriga?

PROBLEM III.

To dispose the globe so as to exhibit the actual situations of the different stars at any time and place.

Elevate the pole according to the latitude of the place, set the globe due north and south, and bring the sun's place and the 12th hour of the horary to the graduated edge of the meridian. Turn the globe towards the east or west, according as the time is before or after noon, until the given hour on the horary comes to the meridian, and the globe will then exhibit the actual situations of the different stars at that time and place.

PROBLEM IV.

To find what stars are rising, setting, or on the meridian at any given time and place.

Dispose the globe as in Problem III.; then the stars corresponding with the eastern edge of the horizon are rising, those corresponding with the western edge are setting, and those under the graduated edge of the brass meridian, are on the meridian of the given place.

EXAMPLES.

On the 9th of February, at nine o'clock in the evening, at London, what stars are rising, what stars are setting, and what stars are on the meridian?

Ans. *Alpheca*, in Corona Borealis, is rising; *Arcturus* and *Mirach*, in the Bootes just above the horizon; *Sirius* on the meridian; the constellations *Orion* and *Taurus* are a little west of the meridian; and *Markab* in Pegasus, just below the western part of the horizon.

On the 2nd of December, when it is six o'clock in the evening at Philadelphia, what stars are rising, setting, and on the meridian?

On the first of October, when it is eight o'clock in the evening, at Quebec, what stars are rising, setting, and on the meridian?

PROBLEM V.

To find the time when any star will rise, set, *or be on the meridian of any place, on a given day.*

Elevate the pole according to the latitude of the given place, and bring the 12th hour of the horary to the meridian. Then bring the star successively to the eastern edge of the horizon, to the meridian, and to the western edge of the horizon, and the times of rising, being on the meridian, and setting, will be respectively shown by the index of the horary.

EXAMPLES.

At what times will *Arcturus* rise, come to the meridian, and set, at London, on the 7th of September?

> *Ans.* It will rise at 7 in the morning, come to the meridian at 3 in the afternoon, and set at 11 at night.

At what times will *Sirius* rise, come to the meridian, and set, at Philadelphia, on the 7th of November?

At what time will *Lyra* rise, come to the meridian, and set, at Philadelphia, on the 10th of August?

PROBLEM VI.

To find the angular distances between the different stars, in degrees.

Lay the quadrant of altitude over any two stars, so that the division marked 0, may be on one of them; the degree of the quadrant over the other star will be the angular distance between them.

EXAMPLES.

What is the angular distance between *Lyra* and *Attair*, in Aquila?

Ans. 34 degrees.

What is the angular distance between *Sirius* and *Aldebaran?*

What is the angular distance between *Dubhe* in Ursa Major, and *Arcturus* in Bootes?

FINIS.

The following Alphabet is given in order to facilitate the reading of those parts of astronomical works in which the Greek letters are used:

Letters.	Names.
Α α	Alpha
Β β ϐ	Bēta
Γ γ ʃ	Gamma
Δ δ	Delta
Ε ε	Epsĭlon
Ζ ζ ʒ	Zēta
Η η	Eta
Θ ϑ θ	Thēta
Ι ι	Iōta
Κ ϰ	Kappa
Λ λ	Lambda
Μ μ	Mu
Ν ν	Nu
Ξ ξ	Xi
Ο ο	Omĭcron
Π ϖ π	Pi
Ρ ρ	Rho
Σ σ ς	Sigma
Τ τ ꞇ	Tau
ϒ υ	Upsilon
Φ φ	Phi
Χ χ	Chi
Ψ ψ	Psi
Ω ω	Omega

.F.L. Bindery,
SEP 19 1888